Severe maternal morbidity in Ireland

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

ANNUAL REPORT 2019

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NOCA National Office of Clinical Audit

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List of Acronyms and Abbreviations

ACVS - Advanced Cardiovascular Support

BCVS - Basic Cardiovascular Support

BMI - Body Mass Index

CCU - Critical Care Unit

CS - Caesarean section

HELLP - Hemolysis, Elevated liver enzymes, and a Low Platelet count syndrome

HDU - High Dependency Unit

HPO - Healthcare Pricing Office

HSE - Health Service Executive

ICU - Intensive Care Unit

LSCS - Lower segment caesarean section

MAP - Morbidly Adherent Placentation

MOH - Major obstetric haemorrhage

MDE Ireland- Maternal death enquiry Ireland

NICU - Neonatal Intensive Care Unit

NOCA - National Office of Clinical Audit

NPEC - National Perinatal Epidemiology Centre

NPRS - National Perinatal Reporting System

PE - Pulmonary embolism

PET - Pre-eclampsia toxaemia

PH - Peripartum hysterectomy

PMR - Perinatal Mortality Rate

SCASMM - Scottish Confidential Audit Severe Maternal Morbidity

SCBU –Special Care Baby Unit

SMC - Severe Maternal Complication

SMM - Severe maternal morbidity

TGCS - Ten Group Classification System (Robson Classification System)

WHO – World Health Organisation

Preface

The NPEC audit on SMM commenced in 2011; during that time, the Irish maternity services has faced many challenges including resourcing issues, increasingly complex pregnancies and increased expectations of women and their families. Despite this, the Irish maternity units have evolved and endeavored to provide excellent care based on International evidence-based practice.

The services have also supported the assessment of care by active and committed involvement in this audit – I commend them for that work and am grateful to all who are involved in providing the care and measuring the outcomes. The provision of data to this audit and other national audits is undertaken by staff often above and beyond their day job. Unit coordinators continue to validate data in the audit process despite many undertaking other jobs including redeployment for COVID-19 work at present. Disappointingly, there remains a lack of real support in resourcing the important work of audit and assessment of care in our services; we once again reflect this in our recommendations.

There have been many positive changes within the Irish maternity services in the intervening years; including the provision of bereavement midwives, the development of the National Women and Infants Health Programme (NWHIP) and the national contribution of data on maternal outcomes to the NPEC to inform practice at a national level. As Director of the NPEC I am grateful that the maternity services in Ireland, through the NPEC, are collecting data that can influence and improve patient care. I wish to acknowledge the effort and time spent participating in the NPEC audits. Maternity units show a real commitment to assessing the care of pregnant women with complex care needs. This report also shows, for the first time, the maternity service commitment to transparency with the identification of individual units in the report.

Studying SMM allows us all to assess the quality of care in our maternity services. The incidence of maternal mortality is now low and there are thankfully fewer cases from which to learn. Examining SMM provides us with opportunities to look at the care provided to women who may indeed be very ill and allows us to identify good practice and areas for improvement. This report adds to a body of evidence that allow for both national and international learning on the maternity services. Working and learning together, we can ensure that all pregnant and recently pregnant women receive safe high-quality care. One of the significant morbidities in this audit is major obstetric haemorrhage; we are aware from other work that postpartum haemorrhage is also increasing in Ireland and other countries. This data is leading to the development of a national quality improvement project by the NWIHP in the evaluation of PPH that will hopefully lead to a reduction in MOH in time.

It is also important that we always consider the data in the context of the individual woman's experience. The significant trauma associated with SMM events during the experience of childbirth can have a profound psychological effect on a woman, her partner, and their families. The input from our public/patient representatives brings this component of morbidity into focus and their input provides great grounding to our endeavours and provides the audits with valuable insight.

I would like to take this opportunity to thank all maternity units in the Republic of Ireland for their ongoing commitment in contributing valuable data on maternity outcomes in

these challenging times. I hope healthcare professionals and others involved in the maternity services will be aware of the findings in this report and use them to the benefit of pregnant and recently pregnant women. We have recently had direct feedback from colleagues about how they use this specific audit report during counselling of women who have sadly had a major morbidity.

"*I have often used these reports over the years when counselling women who have experienced a severe maternal morbidity. As an example, a recent case was a woman who had eclampsia and I was able to show her how rare an event it is but it does occur to a small number of women. She said that she no longer felt alone. That is truly powerful.*"
(Prof Mary Higgins)

"*I found the NPEC SMM report really helpful when counselling a woman who had a peripartum hysterectomy, the woman found it helpful to see she was not alone.*"
(Dr. Cliona Murphy)

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Message from our public representative

"Education is the movement from darkness into light" - Allen Bloom

It is clear from the data collected in this 2019 audit, and on review of year-on-year trends, that the rate of severe maternal morbidity has and is increasing in the 19 maternity units across Ireland. It is also very clear is that pregnant women must be educated on maternal morbidity.

It is the responsibility of the pregnant woman, her General Practitioner and our maternity services to ensure she has an awareness of the complications associated with pregnancy and specifically in relation to maternal morbidity.

The World Health Organisation (WHO) defines maternal morbidity as "any health condition attributed to and/or aggravated by pregnancy and childbirth that has a negative impact on the woman's wellbeing."

The continued collection of data and production of recommendations contained in this report can only lend itself to better outcomes for the pregnant woman. The production of this SMM report and lay summary is the basis of education; educating our medical staff and maternity units but more importantly educating our pregnant women; the partner, wife, sister, mother, friend.

I feel compelled to remind the reader that behind 'the statistics' in this audit report is the experience of a woman at her most vulnerable: while pregnant. My hope is that the recommendations contained in this report, and previous SMM audit reports, are wholeheartedly considered and implemented by the HSE to effect change and improvement for the welfare and outcome of our pregnant women.

Claire Jones
Patient Representative
NPEC Severe Maternal Morbidity Group

Acknowledgements

It is with sincere thanks and appreciation that the NPEC would like to acknowledge the many healthcare professionals who contribute to this NPEC audit on severe maternal morbidity. In particular, we extend our thanks to the unit co-ordinators who continue to co-ordinate the collection of data on severe maternal morbidity at centre level. Their support is commendable as many do so without protected time for clinical audit (see Appendix A). This report would not have been possible without their ongoing dedicated support and co-operation.

The NPEC would like to thank the members of the NPEC Severe Maternal Morbidity Group for their guidance in the continual optimisation of the NPEC national clinical audit of severe maternal morbidity (Appendix B). We are grateful to the group for peer reviewing this report and offering alternative views and interpretations to its findings. We also thank the NPEC Governance Committee, which represents a diverse range of key stakeholders from maternity centres and universities throughout the country, for their support and guidance as the Centre continues to evolve (Appendix C). We acknowledge the National Office of Clinical Audit (NOCA), whose welcomed endorsement of this report is included in Appendix D.

Executive summary

The eighth report from the National Clinical Audit of Severe Maternal Morbidity (SMM) in Ireland reports on 375 cases of SMM occurring in all 19 Irish maternity units in 2019.

The SMM rate is a composite rate of a group of clearly defined severe maternal morbidities. Over two thirds of the women who experienced SMM in 2019 were diagnosed with one morbidity (n=253, 67.5%); 25% (n=95) were diagnosed with two morbidities; 6% (n=24) with three SMMs; 0.5% (n=2) with four morbidities; and 0.3% (n=1) with five morbidities.

The SMM rate has shown a steady increase since the reference year of 2011. From 2011 to 2019, the SMM rate has increased by 68% from 3.85 to 6.47 per 1,000 maternities. The incidence has changed from one case of SMM for every 260 maternities in 2011 to one case in 155 maternities in 2019.

Major obstetric haemorrhage (MOH) remains the most frequently reported SMM event in 2019, accounting for over half (51.2%) of SMM cases. The incidence of MOH cases increased from 2.30 per 1,000 maternities in 2011 to 3.31 per 1,000 maternities in 2019, an overall increase of 44%.

Admission to an intensive or coronary care unit (ICU/CCU) was the second most common event, having been reported in over a third (41.1%) of SMM cases. Contrary to previous years where nearly half of the women admitted to an ICU/CCU had not experienced a SMM as defined in this audit, in 2019, this was recorded for 34% of the women. Additionally, one in five of the women admitted to an ICU/CCU required Level 3 Care (21.4%); 42.9% of the women admitted to ICU/CCU required Level 2 Care and approximately one third required Level 1 Care (34.4%). This highlights that admission to an ICU/CCU in the Irish context does not infer that a woman has a requirement for Level 3 Care.

The next most common reported morbidities were renal or liver dysfunction (8.8%), peripartum hysterectomy (7.5%) and pulmonary embolism (7.2%). These were followed by septicaemic shock (5.1%) and uterine rupture (2.7%).

While there was a consistent rate of peripartum hysterectomy (PH) of approximately 0.33 per 1,000 maternities, in the early years of this national audit, the rate has increased in recent years. In 2017-2019 it was 51% higher than in 2011-2013, at 0.50 per 1,000 indicating that one in every 2000 women experience a PH. Abnormal placentation, primarily morbidly adherent placenta, was the most reported indication for PH (82.2%) followed by MOH with blood loss greater or equal 2.500mls (10.7%).

Variation in rates of SMM and MOH were identified between units. However, differences between units must be interpreted with caution, as they are possibly related to differences in the risk profile of pregnant women presenting to the units rather than the care given. Differences in rates of MOH between units may also reflect variances in practices of estimating blood loss.

For the first time in the SMM audit reports, the risk of SMM according to BMI category was calculated relative to BMI recorded for the pregnant population delivering in Ireland. An association between increased BMI and SMM was identified. The majority (57.8%) of women who experienced a SMM had a high BMI (32.9% overweight and 24.9% obese).

There is an increased risk of SMM associated with multiple pregnancy. The SMM rate associated with multiple pregnancy was three times higher at 17.54 per 1,000 maternities.

The perinatal mortality rate (PMR) associated with women experiencing SMM (27.03 per 1,000 births) was 4.5 times the PMR observed for all births.

Key findings in 2019:

Severe maternal morbidity

- The rate of SMM was 6.47 per 1,000 maternities or one in 155 maternities.
- The SMM rate in 2019 was similar to that in 2018 but it was 68% higher than in the first year of the audit, 2011.
- Variation in rate of SMM and of MOH were identified between units
- MOH remains the most reported morbidity with a rate of 3.31 per 1,000 maternities.
- The reporting of several, less frequent SMMs has increased in recent years, namely, renal or liver dysfunction, peripartum hysterectomy and pulmonary embolism.
- The risk of perinatal mortality associated with SMM was 4.5 times higher than for all births in 2019.

Introduction

This is the eighth report of the national clinical audit on severe maternal morbidity (SMM) in the Republic of Ireland (ROI). In recent decades, SMM has been acknowledged internationally as an important quality indicator of obstetric care and maternal welfare, particularly in developed countries where maternal death rates are relatively low. In this context, the NPEC in collaboration with the NPEC Severe Maternal Morbidity Advisory Group has collected and analysed data on SMM from Irish maternity units since 2011. The fundamental aim of the audit is to provide a national review of clearly defined severe maternal morbidities (SMMs), to identify quality improvement initiatives and make recommendations for the improvement of maternal care for women in Ireland.

This report provides information on the incidence of clearly defined SMM occurring in Ireland in 2019. Information on maternal characteristics, management of delivery and neonatal outcome in women experiencing SMM are also detailed.

Since the inception of the SMM audit, the NPEC has conducted a series of topic-specific case assessment audits on a triennial basis (Figure I). These audits have provided additional valuable information on major obstetric haemorrhage (MOH) for the reporting years 2011-2013 and the level of care provided to the critically ill women in obstetrics for the reporting years 2014-2016. Results of these audits have been reported in annual SMM reports and are available on the NPEC website at https://www.ucc.ie/en/npec/npec-clinical-audits/. For the triennia 2017 to 2019, the NPEC conducted a detailed case assessment audit on women experiencing Pulmonary Embolism (PE) during pregnancy and up to 42 days following the pregnancy end. Due to the small incidence rate in this cohort of women and the power of analysis, findings from this audit will be reported separately in 2021.

Of note, in response to the unprecedented COVID-19 pandemic and the dearth of information of its impact on the pregnant population and neonates, the NPEC developed a register and audit of pregnant women and neonates in the ROI. This is intended to add to a body of international evidence in order to inform clinical practice, families and public health policy. From January 2021, the new MOH specific audit has been launched, collecting detailed data on every case of MOH diagnosed in any of the Irish maternity hospitals.

In this 2019 report the maternity units are identified in the Funnel plots detailing SMM and MOH rates across units. This development aims to facilitate greater transparency in the maternity services and follows engagement with all maternity units, the NPEC Governance Committees and the National Office of Clinical Audit (NOCA).

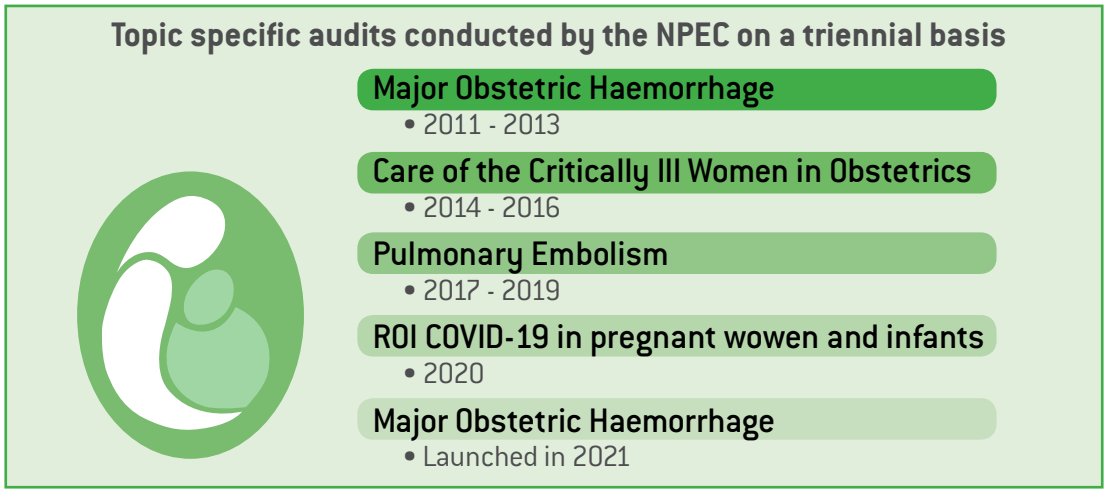


Figure I: Topic-specific audits conducted by the NPEC on a triennial basis

Recommendations

Recommendations from previous reports that have been progressed

Recommendation:

- *'A quantitative approach involving **volume and weight assessment to estimate blood loss** should be considered for use in all maternity units. **Development of a national tool-kit** would assist standardisation of such an approach.'*

  The National Women and Infants Health Programme (NWHIP), in collaboration with the NPEC, have convened a multidisciplinary group to develop a national quality improvement initiative to evaluate rising post-partum haemorrhage (PPH) rates. This will include development of a standardised national tool-kit to estimate PPH and a focus on identifying better management of PPH to reduce numbers of MOH cases

Recommendation:

- *The **implementation of a case assessment audit of major obstetric audit (MOH)** is essential as it continues to be the leading cause of severe maternal morbidity.*

The NPEC has refined the MOH case assessment audit tool (2011-2013) and developed a secure online database for the upcoming audit to be implemented. This audit was implemented nationally in January 2021.

Based on findings from this and previous reports, the NPEC Severe Maternal Morbidity Group makes the following recommendations.
Organisations have been identified to take ownership of progressing these recommendations.

Recommendation:

- Robust clinical audit on adverse maternal outcomes requires the **protected time of clinical staff.** The NPEC will continue to advocate for this. Funding should be provided by the Health Service Executive (HSE) to facilitate the same.

- A **public health education programme on maternal morbidity and modifiable risk factors** should be developed. Owner; the National Women and Infants Health Programme (NWHIP) to progress this.

- **Antenatal education:**
  a) Antenatal education/information should be provided by the multidisciplinary team to ensure an understanding of maternal morbidity and complication awareness.
  b) When a pregnant woman is identified as high risk for significant morbidity, specific education should be available to her during antenatal birth preparation.
  c) The national standards on antenatal education should provide guidance on specific education for maternal morbidity awareness.

- **Research on the incidence of morbidly adherent placenta in Ireland** is warranted. Owner; the NPEC to progress this.

- Internationally, **social inequalities** have been shown to impact on risk of SMM. There is a need to establish the evidence in this regard in Ireland. This **requires improved maternity data at national level** and more research in order to establish this evidence.

  - There is an opportunity with the Maternal Newborn Clinical Management System (MN_CMS) data from Irish maternity units. **These data could be collated to identify the influence of risk factors for SMM in Ireland** including ethnicity, maternal age, body mass index (BMI), smoking, employment status and other socio-economic factors. This should overcome the current deficit in the pregnant population data Owner; the NPEC to progress this.

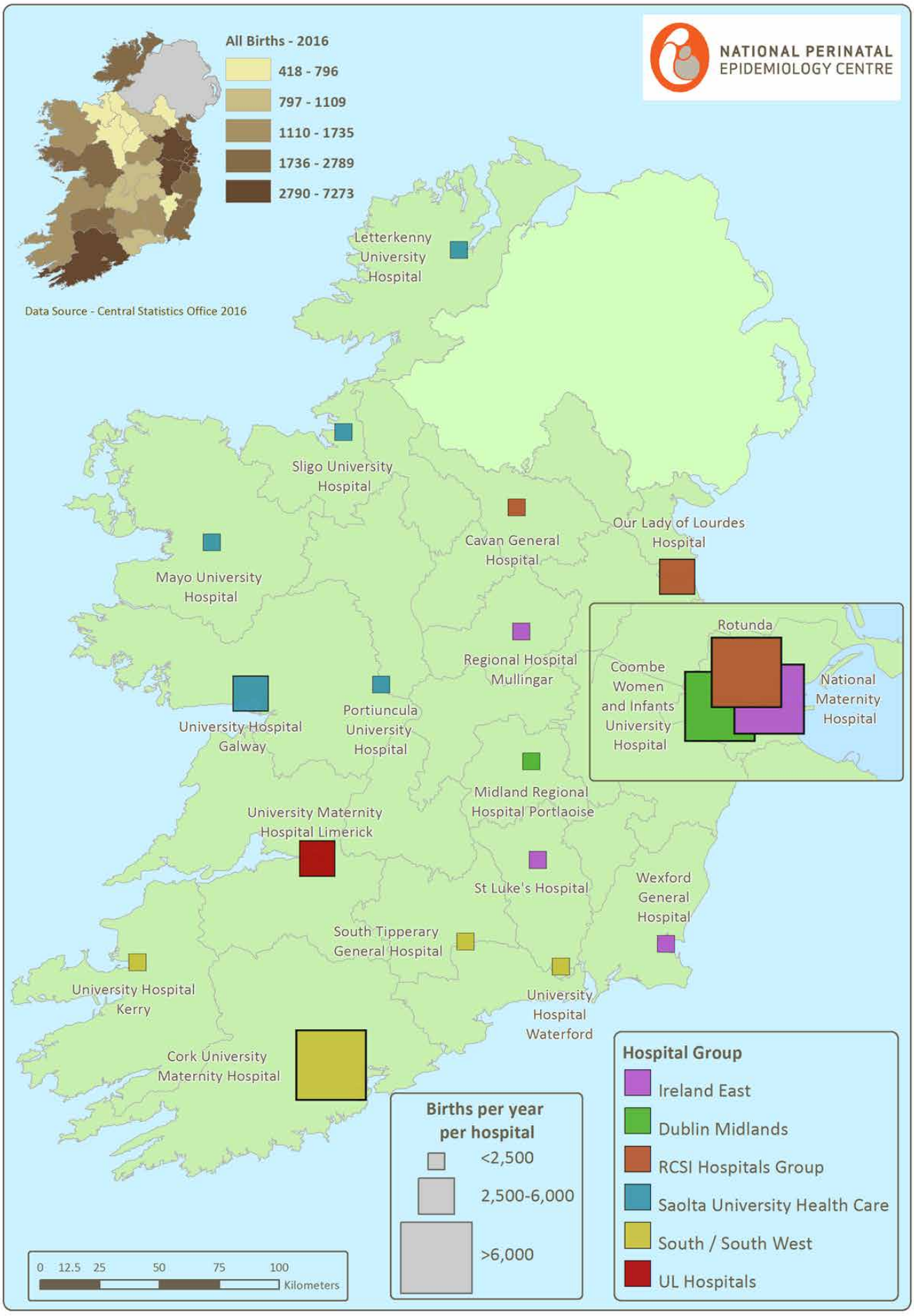


Figure II: Map of maternity units and hospital groups in the Republic of Ireland, 2019

Methods

To allow for international comparison, the NPEC adapted the validated methodology of the Scottish Confidential Audit of Severe Maternal Morbidity (SCASMM) to evaluate severe maternal morbidity (SMM) in Ireland. This methodology utilises organ dysfunction criteria described by Mantel et al,[1] with modifications used by SCASMM to include intervention - based criteria.[2] Implemented nationally in 2011, this data collection tool, adapted for the Irish setting, has been endorsed by the Clinical Advisory Group at the Institute of Obstetrics and Gynaecology and the HSE National Obstetric Programme Working Group.

Data recording

Since the inception of the audit in 2011, all but one maternity unit has contributed data for the years 2011, 2012, 2014 and 2015, with all maternity units submitting data for the years 2013 and since 2016. In 2019, there were 19 maternity units in the Republic of Ireland. Data on SMM events occurring between 1 January and 31 December 2019 were submitted using a standardised notification dataset, either electronically via the secure online NPEC database or alternatively by paper format (Appendix E). The dataset is completed based on data on maternal and fetal characteristics recorded in clinical records. The data are subsequently processed by NPEC in a pseudonymised format, which means that they cannot be attributed to a specific individual without the use of additional information, and only the submitting unit has access to this information.

Figure III illustrates the NPEC data collection and management processes. There has been a steady improvement in the overall quality of data reported by maternity units since the implementation of the NPEC SMM notification dataset in 2011. However, the timeliness of data submission remains a challenge in maternity units. Feedback to the NPEC has identified that the lack of dedicated resources for clinical audit impacts negatively on the collation of data at local level.

Recommendations:

- Robust clinical audit on adverse maternal outcomes requires the protected time of clinical staff. Funding should be provided by the Health Service Executive (HSE) to facilitate same.

1 Mantel G et al. Severe Acute maternal morbidity: a pilot study of a definition for a near-miss. BJOG 1998; 105: 985-90
2 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

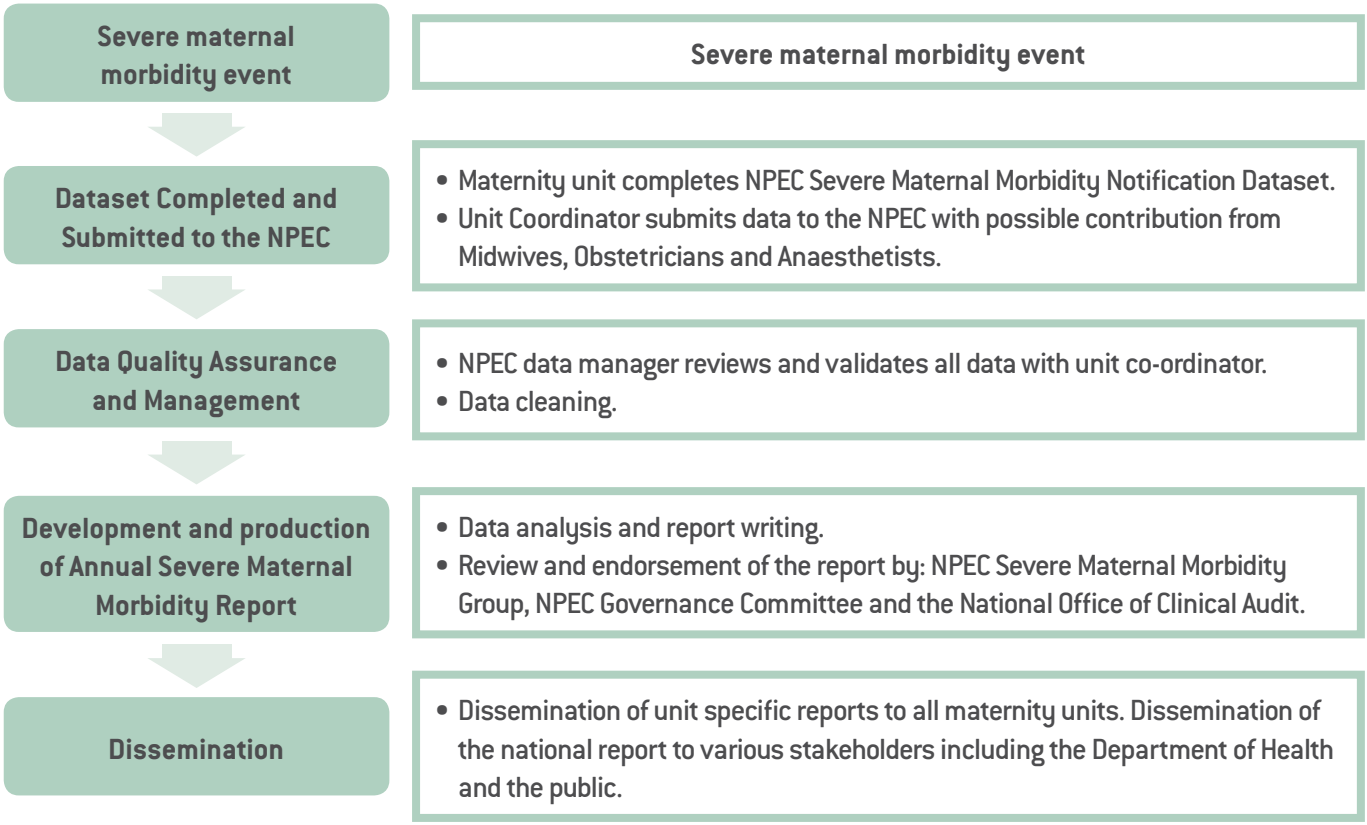


Figure III: NPEC data collection and management processes.

Definitions and inclusion criteria for the audit

In this audit, a case of severe maternal morbidity (SMM) was defined as a pregnant or recently pregnant woman (i.e. up to 42 days following the pregnancy end) who experienced any of the following fourteen, clearly defined, organ dysfunction morbidities in the reporting years 2013-2019: major obstetric haemorrhage (MOH), uterine rupture, eclampsia, renal or liver dysfunction, pulmonary oedema, acute respiratory dysfunction, pulmonary embolism, cardiac arrest, coma, cerebrovascular event, status epilepticus, septicaemic shock, anaesthetic complications and maternities involving peripartum hysterectomy. To allow for direct comparison with the SCASMM, two management proxies for maternal morbidity - ICU/CCU admission and interventional radiology - were also included. Definitions for all reportable SMM events are provided at the end of the notification form (Appendix E).

The SCASMM methods, adopted by this SMM national audit, defined MOH as occurring if one of the following criteria were met: estimated blood loss of at least 2,500ml; transfusion of five or more units of blood; and, receiving treatment for coagulopathy. In recent years, there has been an increase in the number of MOH cases reported solely because treatment was received for coagulopathy, which reflects change in practice. In order to adjust for this change in practice, the MOH findings in this report are based on MOH cases with an estimated blood loss of at least 2,500ml or a transfusion of five or more units of blood. Similarly, the SMM findings are based on these MOH cases and cases of any of the other SMMs listed above.

In 2013-2019, uterine rupture was a specified morbidity for the audit whereas this was not the case in 2011, the first year of the audit. This change has led to a small increase in reportable cases of SMM. However, most cases of uterine rupture meet the criteria for major obstetric haemorrhage and were therefore reported in all eight years of the audit.

Ten Group Classification System

In 2019, 17 of the 19 units that participated in the SMM audit also provided data on women who gave birth classified according to the Ten Group Classification System[3] (TGCS; Appendix F). The incidence of MOH aggregated for these 17 units was classified according to the TGCS.

Rate calculations

The SMM rate is a composite rate of a group of clearly defined severe morbidities. In keeping with the international published literature in this area, the incidence rate of SMM and of specific morbidities are calculated per 1,000 maternities resulting in the live birth or stillbirth. For incidence rates, 95% confidence intervals were calculated using exact Poisson confidence limits unless stated otherwise.

Funnel plots are used to illustrate both the variation in incidence rates across participating maternity units and the deviation of the rate for each individual unit from the national rate.

All denominator data used for this report were based on the number of women who gave birth in hospital (maternities) as enumerated by the Hospital In-Patient Enquiry (HIPE), operated by the Healthcare Pricing Office (www.hpo.ie).

The denominator based on number of women who gave birth underestimates the number of women at risk of SMM as it does not include women experiencing miscarriage, ectopic pregnancy and molar pregnancy, which may be reported as cases of SMM and thereby are included in the numerator. However, complete data on maternities resulting in miscarriage, ectopic pregnancy and molar pregnancy are not available and so, to ensure uniformity, the denominator was restricted to women who gave birth to a live born or stillborn baby. The approach of not including miscarriage, ectopic pregnancy and molar pregnancy in the denominator was also the approach taken by the SCASMM and confidential enquiries on maternal deaths in Ireland and the UK.[4,5,6]

The infrequency of some specific rarer SMMs compared to those more frequently recorded, such as MOH and ICU/CCU admission, makes it difficult to assess time trends based on the annual rate. The nine-year time period of the SMM audit is now long enough to allow these morbidities time trend to be examined by triennium. Hence, rates of renal dysfunction, peripartum hysterectomy, pulmonary embolism and septicaemic shock were calculated by triennium.

The absence of national data on BMI, ethnicity, social-economic status among others, means that the risk of SMM associated with these factors remains unknown. Internationally, social inequalities have been shown to impact on the risk of SMM. There is a need to establish the evidence in this regard in Ireland.

Rate ratios

Further analysis was conducted to assess variation in incidence rates between years, maternal age groups, and single and multiple pregnancies. This analysis involved using Poisson regression which calculates a rate ratio (for example, the rate in one year divided by the rate in the previous year). Rate ratios have the advantage of being easy to interpret. They are interpreted against the rate to which they are being compared (the reference group/reference rate). A rate ratio is greater than one if a rate is greater than the rate to

3 Robson MS (2001). Classification of caesarean sections. Fetal and Maternal Medicine Review, 12, pp 23-39 doi:10.1017/S0965539501000122.
4 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx
5 O'Hare MF, Manning E, Corcoran P, Greene RA on behalf of MDE Ireland. Confidential Maternal Death Enquiry in Ireland, Report for 2013 - 2015. Cork: MDE Ireland, December 2017.
6 Knight M, Bunch K, Tuffnell D, Jayakody H, Shakespeare J, Kotnis R, Kenyon S, Kurinczuk JJ (Eds.) on behalf of MBRRACE-UK. Saving Lives, Improving Mothers' Care - Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2015-17. Oxford: National Perinatal Epidemiology Unit, University of Oxford 2019

which it is being compared. For example, a rate ratio of 1.25 indicates the rate being examined is 25% higher than (or 1.25 times) the rate to which it is being compared. Conversely, a rate ratio will be less than one if a rate is less than the rate to which it is being compared. For example, a rate ratio of 0.80 indicates that the rate being examined is equivalent to 80% of the rate to which it is being compared, i.e. it is 20% lower. The Poisson regression analysis provides a 95% confidence interval for the rate ratio and the associated p-value, both of which indicate whether the rate difference is in line with what might be expected due to chance. A rate difference is considered to be beyond what might be expected by chance, i.e. statistically significant, if the 95% confidence interval for the rate ratio does not include the value one. This is equivalent to the p-value derived from the analysis being less than 0.05. If the p-value is less than 0.001 then the rate difference may be considered highly statistically significant.

Funnel plots

Variations in SMM between maternity units could potentially be due to random chance or reflect differences in baseline characteristics of the childbearing population. For this reason, funnel plots were used to assess performance outcomes for individual units in comparison to the overall average.[7] In brief, the plot is a scatter diagram of individual maternity unit SMM rates against the number of maternities within that unit. The national rate is indicated by the solid straight line. The 95% confidence interval is indicated by the curved dashed line. The dashed lines represent the limits within which 95% of units are expected to lie (i.e. within two exact binomial standard errors). The 99.8% confidence interval for the national rate is plotted using solid lines. These solid lines represent the limits within which 99.8% of units are expected to lie (i.e. within three exact binomial standard errors). The width of the confidence interval is adjusted to allow for a meaningful comparison between unit-specific rates and the national rate. The confidence interval is wider for smaller units reflecting the lack of precision in rates calculated based on small numbers. The confidence interval narrows for larger maternity units, giving the diagram a 'funnel' shape. Maternity unit rates outside the 95% and 99.8% confidence interval are statistically significantly different from the national rate. In general, one in 20 units would be expected to lie outside the 95% confidence limits by chance alone whereas an observation outside the 99.8% confidence limits is especially rare, i.e. there is a 0.2% chance of this happening (Figure IV).

Some of the variation in rates across maternity units will be due to differences in the profile of the women attending the maternity units. Data are not available to allow for adjustment of the profile of women attending the country's maternity units. For this reason, we recommend a conservative interpretation of differences between the rates of units and their deviation from the national rate.

7 Spiegelhalter D. (2002) Funnel plots for institutional comparison. Quality and Safety in Health Care; 11(4):390-91.

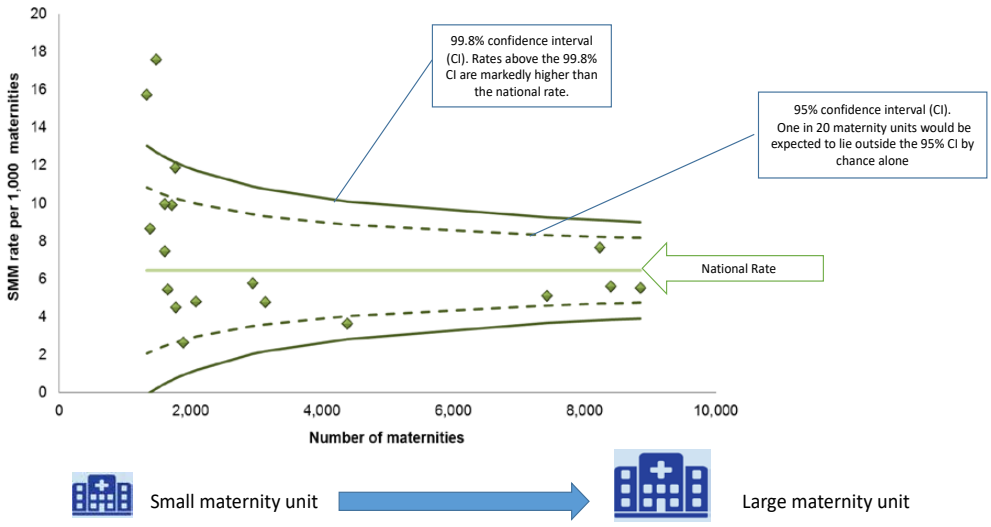


Figure IV: Diagram outlining the interpretation of a funnel plot

Data Quality Statement

In the NPEC the maintenance of data at high quality standards is a priority. The purpose of this data quality statement is to support the interpretation and quality of the information contained in this report.

This quality statement, presented in Appendix G, has been developed in line with the Health Information and Quality Authority (HIQA) guidance on data quality framework for health and social care.[8] The statement describes the quality of the data according to five data quality dimensions as defined by HIQA:

1. Relevance
2. Accuracy and reliability
3. Timeliness and punctuality
4. Coherence and comparability
5. Accessibility and clarity

The National Clinical Audit of Severe Maternal Morbidity adheres to following national and international legislation and standards:

- The European Union General Data Protection Regulation 2016
- The Data Protection Act 1988 and the Data Protection (Amendment) Act 2003
- Data Protection Act 2018 (Section 36(2)) (Health Research) Regulations 2018
- Information Management Standards for National Health and Social Care Data (2017)
- National Office of Clinical Audit Standards for National Clinical Audit
- National Standards for Safer Better Healthcare (2012)
- FAIR (Findable, Accessible, Interoperable, and Re-usable) Data Principles

8 Health Information and Quality Authority. (2018) Guidance on a data quality framework for health and social care 2018. Available from https://www.hiqa.ie/sites/default/files/2018-10/Guidance-for-a-data-quality-framework.pdf

Main Findings

National rate

In 2019, the 19 Irish maternity units reported that 375 women experienced SMM as defined in this audit. Table 1 details the national number of cases, total maternities and SMM rates derived from the participating units since the first year of the audit, 2011.

Table 1: Incidence of severe maternal morbidity (SMM) in Ireland, 2011-2019

Year	Maternities (n)	SMM cases (n)	SMM rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	255	3.85 (3.39-4.36)	1.00 (ref.)	---
2012	64,184	278	4.33 (3.84-4.87)	1.12 (0.95-1.33)	0.177
2013	66,073	307	4.65 (4.14-5.20)	1.21 (1.02-1.42)	0.027
2014	61,182	347	5.67 (5.09-6.30)	1.47 (1.25-1.73)	<0.001
2015	59,497	355	5.97 (5.36-6.62)	1.55 (1.32-1.82)	<0.001
2016	62,417	387	6.20 (5.60-6.85)	1.61 (1.37-1.88)	<0.001
2017	60,480	372	6.15 (5.54-6.81)	1.60 (1.36-1.87)	<0.001
2018	59,592	382	6.41 (5.78-7.09)	1.66 (1.42-1.95)	<0.001
2019	57,983	375	6.47 (5.83-7.16)	1.68 (1.43-1.97)	<0.001

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

From 2011 to 2019, the SMM rate increased by 68% from 3.85 to 6.47 per 1,000 maternities. The incidence has changed from one case of SMM for every 260 maternities in 2011 to one case in 155 maternities in 2019.

Specific severe maternal morbidities

The SMM rate is a composite rate of a group of clearly defined severe maternal morbidities. Over two thirds of the women who experienced SMM in 2019 were diagnosed with one morbidity (n=253, 67.5%); 25% (n=95, 25.3%) were diagnosed with two morbidities; 6% (n=24, 6.4%) with three SMMs; 0.5% (n=2, 0.5%) with four morbidities; and 0.3% (n=1, 0.3%) with five morbidities.

As in recent years, major obstetric haemorrhage (MOH) was the most commonly reported morbidity in 2019, accounting for half of all SMM cases (Table 2). The other common SMM was ICU/CCU admission, which was experienced by 154 women. The next most frequently reported SMM events were renal or liver dysfunction (8.8%), peripartum hysterectomy (7.5%), pulmonary embolism (7.2%) and septicaemic shock (5.1%). The remaining ten specific SMMs were relatively rare, being experienced by fewer than fifteen women with each accounting for no more than 3% of the reported SMM cases.

Table 2: Incidence of specific severe maternal morbidities (SMMs) in Ireland, 2019

	n(%)
Incidence of organ dysfunction SMM	
Major obstetric haemorrhage	192(51.2)
Renal or liver dysfunction	33(8.8)
Peripartum hysterectomy	28(7.5)
Septicaemic shock	19(5.1)
Pulmonary embolism	27(7.2)
Eclampsia	8(2.1)
Acute respiratory dysfunction	7(1.9)
Uterine rupture	10(2.7)
Pulmonary oedema	7(1.9)
Anaesthetic problem	6(1.6)
Cerebrovascular event	4(1.1)
Cardiac arrest	5(1.3)
Coma	0(0)
Status epilepticus	0(0)
Incidence of SMM based on management criteria	
ICU/CCU admission	154(41.1)
Interventional radiology	14(3.7)
Total women affected	**375(100)**

Note: n represents the number of women affected by the specific morbidity; more than one morbidity may apply per woman % is based on the total number of women affected; ICU=intensive care unit; CCU=coronary care unit.

Major obstetric haemorrhage

Of the 192 MOH cases in 2019, 70% (n=134) involved an estimated blood loss ≥2,500ml without a transfusion of ≥5 units of blood, one in four MOH cases (n=45, 23.4%) met both criteria and 7% (n=13, 6.8%) involved a transfusion of ≥5 units of blood with an estimated blood loss <2,500ml.

The vast majority of MOH occurred postnatally on day of delivery (n=165, 86% of 192), with a further 19 cases occurring in the postnatal period (day 1 to day 42 post-delivery) and 8 (4%) were recorded as antenatal events. Thirteen (6.8%) of the 192 cases of MOH reported in 2019 were associated with early pregnancy loss and occurred between five and eighteen weeks of gestation. For the other 179 women who experienced MOH, 105 had delivery by caesarean section and 73 had a vaginal delivery (mode of delivery was unreported for two women).

In 2019 the provision of termination of pregnancy (TOP) services was launched in the ROI. Similar to early pregnancy loss and ectopic pregnancy, MOH and SMM following TOP are reportable events in this NPEC audit. For the year 2019, there were no MOH, or any other reportable SMM, recorded as a complication of a TOP.

The increasing rates of MOH warrant further investigation. The case assessment of MOH remains a priority for the NPEC and the audit

specifically focussed on this has recommenced in 2021. This will enhance learning and identify any possible change in practice, risk factors or in the profile of the pregnant population impacting on MOH rates.

Trends in major obstetric haemorrhage (MOH)

There were 192 MOH cases in 2019 giving a rate of 3.31 per 1,000 maternities (Table 3). This is similar to the incidence in 2018 but over the nine years of the national audit there has been a 44% increase in the MOH rate. This remains one of the main challenges for service providers and clinical staff as highlighted in a recent research study on increasing MOH rates in Ireland.[9]

Table 3: Incidence of major obstetric haemorrhage (MOH) in Ireland, 2011-2019

Year	Maternities (n)	MOH cases (n)	MOH rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	152	2.30 (1.95-2.69)	1.00 (ref.)	---
2012	64,184	149	2.32 (1.96-2.73)	1.01 (0.81-1.27)	0.925
2013	66,073	157	2.38 (2.02-2.78)	1.03 (0.83-1.29)	0.764
2014	61,182	149	2.44 (2.06-2.86)	1.06 (0.85-1.33)	0.611
2015	59,497	159	2.67 (2.27-3.12)	1.16 (0.93-1.45)	0.181
2016	62,417	192	3.08 (2.66-3.54)	1.34 (1.08-1.66)	0.007
2017	60,480	169	2.79 (2.39-3.25)	1.22 (0.98-1.51)	0.079
2018	59,592	190	3.19 (2.75-3.68)	1.39 (1.12-1.72)	0.003
2019	57,983	192	3.31 (2.86-3.81)	1.44 (1.17-1.78)	<0.001

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

9 Greene RA, McKernan J, Manning E, Corcoran P, Byrne B, Cooley S, et al. Major obstetric haemorrhage: Incidence, management and quality of care in Irish maternity units. European Journal of Obstetrics and Gynecology and Reproductive Biology. 2021;257:114-20.

Intensive care unit/coronary care (ICU/CCU) unit admission

Table 4 details the specific SMMs involved in the 154 cases admitted into an ICU/CCU in 2019. Nearly 45% of these cases involved MOH, 5.8% involved septicaemic shock and nine cases related to PH (5.8%). A further 4.5% of ICU admissions involved acute respiratory dysfunction and a similar proportion related to renal or liver dysfunction.

Table 4: Specific severe maternal morbidities (SMMs) in women admitted to an intensive care unit or coronary care unit (ICU/CCU) in Ireland, 2019

	n(%)
Total women admitted to ICU/CCU	**154(100)**
Major obstetric haemorrhage	68(44.2)
Septicaemic shock	9(5.8)
Peripartum hysterectomy	9(5.8)
Renal or liver dysfunction	7(4.5)
Acute respiratory dysfunction	7(4.5)
Pulmonary embolism	9(5.8)
Pulmonary oedema	3(1.9)
Anaesthetic problem	3(1.9)
Interventional radiology	4(2.6)
Eclampsia	3(1.9)
Cerebrovascular event	2(1.3)
Uterine rupture	2(1.3)
Cardiac arrest	5(3.2)
Status epilepticus	0(0)
Coma	0(0)
None of the above*	53(34.4)

Note: n represents the number of women affected by the specific morbidity; % is based on the total number of women admitted to ICU/CCU in 2019. More than one morbidity may apply per woman; *women admitted to ICU/CCU due to other morbidities or other issues not listed.

Over one third of the women admitted into an ICU/CCU in 2019 had not experienced a SMM as defined in this audit ("none of the above", 34.4%, n=53/154). Despite the values registered in the past 2 years where a stabilisation in the occurrence of this phenomenon was observed, the values for 2019 represent a decline in the proportion of cases admitted to ICU for other SMMs not specified in this audit (Figure 2). As acknowledged in previous reports, admission to ICU/CCU in cases not meeting the criteria of SMM as defined in this audit does not imply inappropriate use of ICU/CCU facilities but suggests the requirement of a higher level of observation or maternal care in units with limited resources.

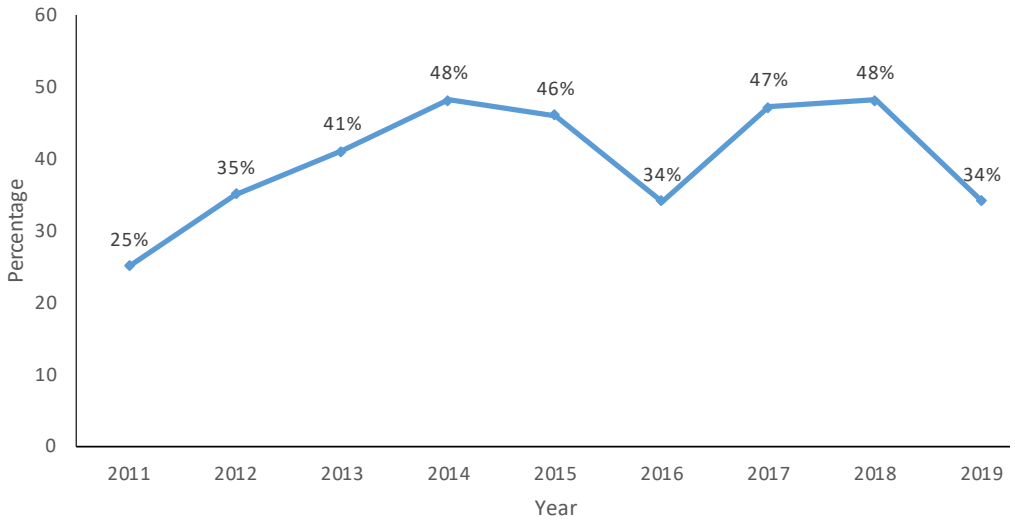


Figure 1: Proportion of cases admitted to ICU/CCU not experiencing a severe morbidity as defined in this audit, 2011-2019

These cases, requiring a higher level of observation (Level 1, 2 or 3 Care), were associated with a wide variety of maternal complications due to both direct obstetric (n=34, 64.2%) and non-obstetric causes (n=19, 35.8%). Direct obstetric complications included Pre-eclampsia toxaemia (PET) and HELLP (n=14, 41.2%), post-partum haemorrhage (PPH) with a blood loss <2,500ml (n=10, 29.4%), pregnancy-related infection (n=8, 23.5%) and monitoring post Lower segment caesarean section (LSCS; n=2, 5.9%). ICU admissions due to non-obstetric complications (n=19, 35.8%) primarily included monitoring of cardiac and neurological conditions, non-obstetric sepsis, and endocrine complications among other conditions.

The vast majority of ICU/CCU admissions with no other reported morbidity as defined in this audit (n=53) occurred in small maternity units (n=41, 77.4%). Over half of these 41 cases (n=24, 58.5 %) occurred in three small units with on-site ICU/CCU facilities but without obstetric high dependency facilities. Feedback from these units in previous years indicated that the rate of such ICU/CCU admissions reflected resource issues in cases where women required a higher level of monitoring. Of the 24 ICU admissions, in these three units, with no other SMM as defined in this audit: none required Level 3 Care, over half required Level 2 Care (n=14, 58.3%) and the remaining women required Level 1 Care (n=10, 41.7%).

The correlation between maternity units with a birth rate less than 2,500 per annum and increased likelihood of Level 2 care provided in ICU/CCU facilities was identified in the NPEC National Audit of Critically Ill Women in Obstetrics.[10]

10 Manning E, Leitao S, Corcoran P, McKernan J, de Foubert P, Greene RA, on behalf of the Severe Maternal Morbidity Group. *Section 2 Confidential Audit of Critical Care in Obstetrics in Ireland* in the Severe Maternal Morbidity in Ireland Annual Report 2016. Cork: National Perinatal Epidemiology Centre, 2018.

Trends in ICU/CCU admissions

A total of 154 women experienced intensive care unit/coronary care unit (ICU/CCU) admission in 2019, a rate of 2.66 per 1,000 maternities. The rate of ICU/CCU admission increased during the first years of the SMM audit, reaching 3.04 per 1,000 maternities in 2015. Since then this rate has been steady at 2.7-2.9 per 1,000.

Table 5: Incidence of intensive care unit/coronary care unit (ICU/CCU) admission in Ireland, 2011-2019

Year	Maternities (n)	ICU/CCU admissions (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	111	1.68 (1.38-2.02)	1.00 (ref.)	---
2012	64,184	130	2.03 (1.69-2.41)	1.21 (0.94-1.56)	0.144
2013	66,073	131	1.98 (1.66-2.35)	1.18 (0.92-1.52)	0.194
2014	61,182	171	2.79 (2.39-3.25)	1.67 (1.31-2.12)	<0.001
2015	59,497	181	3.04 (2.62-3.52)	1.81 (1.43-2.30)	<0.001
2016	62,417	160	2.56 (2.18-2.99)	1.53 (1.20-1.95)	<0.001
2017	60,480	149	2.46 (2.08-2.89)	1.47 (1.15-1.88)	0.002
2018	59,592	156	2.62 (2.22-3.06)	1.56 (1.22-1.99)	<0.001
2019	57,983	154	2.66 (2.25-3.11)	1.58 (1.24-2.02)	<0.001

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

Figure 2 illustrates the trend in the rate of SMM as defined in this audit and the separate trends for MOH and ICU/CCU admission. An almost linear increase in the rate of SMM is evident from 3.85 to 6.47 per 1,000 maternities over the nine years. The increase in the SMM rate during the first half of this time period was primarily due to the increase in ICU/CCU admissions. During the more recent years, the increase in the SMM rate largely reflected the increase in MOH.

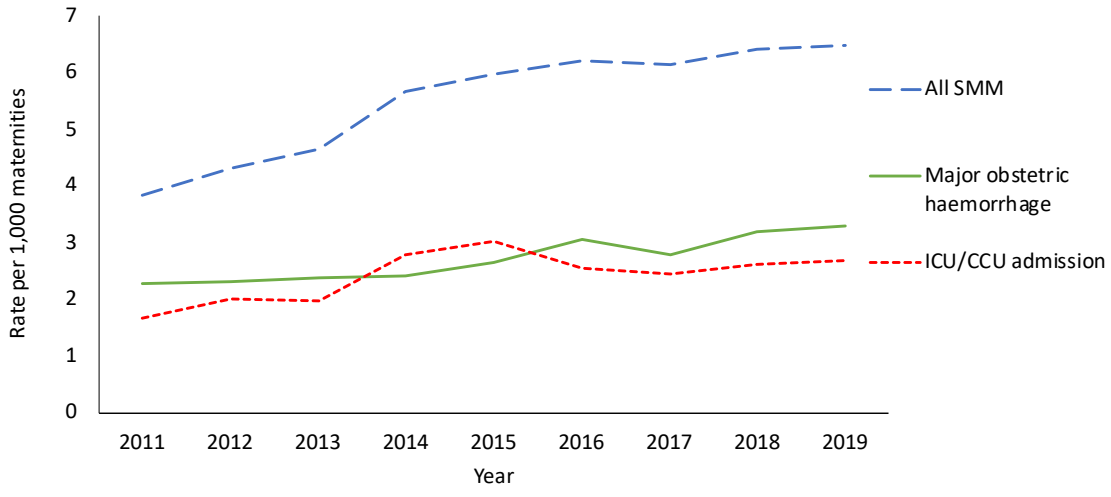


Figure 2: Trend in the rate of severe maternal morbidity (SMM), major obstetric haemorrhage and intensive care unit/coronary care unit (ICU/CCU) admission, 2011-2019

Trends in renal or liver dysfunction

The infrequency of some specific SMMs, such as renal or liver dysfunction, compared to MOH and ICU/CCU admission makes it difficult to assess time trends based on the annual rate. The nine-year time period of the SMM audit is long enough to allow their time trend to be examined by triennium. The 69 cases of renal or liver dysfunction reported in 2011-2013 gave a rate of 0.35 per 1,000 maternities. The rate of reported cases has increased steadily, doubling to 0.70 per 1,000 by 2015-2017 and then remaining steady at approximately 0.63-0.64 per 1,000 since then (p-value<0.001).

Table 6: Incidence of renal or liver dysfunction in Ireland, 2011-2019

Year	Maternities	Renal/liver dysfunction	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	69	0.35 (0.27-0.44)	1.00 (ref.)	---
2012-14	191,439	82	0.43 (0.34-0.53)	1.22 (0.89-1.68)	0.225
2013-15	186,752	104	0.56 (0.46-0.67)	1.59 (1.17-2.15)	0.003
2014-16	183,096	117	0.64 (0.53-0.77)	1.82 (1.35-2.45)	<0.001
2015-17	182,394	128	0.70 (0.59-0.83)	2.00 (1.49-2.68)	<0.001
2016-18	182,489	115	0.63 (0.52-0.76)	1.79 (1.33-2.42)	<0.001
2017-19	178,055	114	0.64 (0.53-0.77)	1.82 (1.35-2.46)	<0.001

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

Trends in peripartum hysterectomy

In the early years of this national audit, there was a consistent rate of peripartum hysterectomy of approximately 0.33 per 1,000 maternities (Table 7). This is equivalent to one in every 3000 women experiencing a peripartum hysterectomy. The rate has increased in recent years and in 2017-2019 it was 51% higher than in 2011-2013, at 0.50 per 1,000 (p-value<0.011). This indicates that one in every 2000 women in Ireland experience a peripartum hysterectomy.

This Irish rate is marginally higher than the rate reported in earlier studies in the United Kingdom (0.41 per 1,000 births)[11] but it is lower than the rate reported in the USA and Australia (0.82 per 1,000 and 0.85 per 1,000 respectively).[12,13]

11 Knight M, Kurinczuk JJ, Spark P and Brocklehurst P. United Kingdom Obstetric Surveillance System Steering Committee. Caesarean delivery and peripartum hysterectomy, Obstet Gynecol 2008; 111 January (1); 97-105
12 Bateman BT, Mhyre JM, Callaghan WM, Kuklina EV. Peripartum hysterectomy in the United States: nationwide 14 year experience. Am J Obstet Gynecol 2012;206(January (1))63 e1-8.
13 Awan N, Bennett MJ, Walters WA. Emergency peripartum hysterectomy: a 10- year review at the Royal Hospital for Women, Sydney. Aust N Z J Obstet Gynaecol 2011;51(June (3)):210–5.

Table 7: Incidence of peripartum hysterectomy in Ireland, 2011-2019

Year	Maternities	Peripartum hysterectomy	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	65	0.33 (0.26-0.42)	1.00 (ref.)	---
2012-14	191,439	63	0.33 (0.25-0.42)	0.99 (0.70-1.41)	0.975
2013-15	186,752	57	0.31 (0.23-0.40)	0.92 (0.65-1.32)	0.656
2014-16	183,096	64	0.35 (0.27-0.45)	1.06 (0.75-1.49)	0.755
2015-17	182,394	76	0.42 (0.33-0.52)	1.26 (0.90-1.75)	0.172
2016-18	182,489	88	0.48 (0.39-0.59)	1.46 (1.06-2.01)	0.021
2017-19	178,055	89	0.50 (0.40-0.62)	1.51 (1.10-2.08)	0.011

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

Of the 28 PH cases occurring in 2019, 64.3% (n=16) occurred in 3 large tertiary referral units of which 7 were reported in women following in-utero transfer. The further 12 of the 28 PH cases were performed across 6 maternity units.

Morbidly adherent placenta (MAP) is a recognised risk factor for peripartum hysterectomy.[14] A study conducted by the NPEC confirmed the established association between previous caesarean section (CS), MAP and PH.[15] In this 2019 SMM audit, abnormal placentation (n=23), primarily MAP, was the most reported indication for PH (23/28, 82.2%), followed by MOH with a blood loss ≥2.500ml (3/28, 10.7%). A further 2 cases were associated with infection (n=1) and a large necrotic fibroid (n=1). The vast majority of PH cases involved delivery by CS (n=25) and most of the women had a previous CS (n=22, 78.6%). This highlights the value of research on the incidence and risk factors associated with MAP.

In this SMM audit between 2017-2019, a total of 89 cases of PH were reported. Abnormal placentation, primarily MAP, was the most reported indication for PH (71/89, 79.8%), followed by MOH with a blood loss ≥2.500ml (15/89, 16.9%). Further indications for PH included cervical cancer (n=1), infection (n=1), a large necrotic fibroid (n=1). The vast majority of PH cases involved delivery by CS (n=82, 92.1%) and most of the women had a previous CS (n=68, 76.4%). This highlights the value of research on the incidence and risk factors associated with MAP.

Recommendation:

- In light of the increasing rates of peripartum hysterectomy associated with morbidly adherent placenta (MAP) further research on the incidence of morbidly adherent placenta is warranted.

14 Kallianidis AF, Maraschini A, Danis J, Colmorn LB, Deneux-Tharaux C, Donati S, et al. Epidemiological analysis of peripartum hysterectomy across nine European countries. 2020; 99(10):1364-73.
15 Campbell, Sarah M. et al. Peripartum hysterectomy incidence, risk factors and clinical characteristics in Ireland. Eur J Obstet Gynecol Reprod Biol 2016, Volume 207, 56 - 61

Trends in pulmonary embolism

The incidence of reported cases of pulmonary embolism (PE) has increased by 65% over the nine years of the SMM audit (Table 8). The rate of 0.24 per 1,000 maternities in 2011-2013 indicates that one women in approximately 4,000 experienced PE. The rate of 0.40 per 1,000 indicates that in 2017-2019 one woman in 2,500 experienced PE.

Table 8: Incidence of pulmonary embolism in Ireland, 2011-2019

Year	Maternities	Pulmonary embolism	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	48	0.24 (0.18-0.32)	1.00 (ref.)	---
2012-14	191,439	53	0.28 (0.21-0.36)	1.13 (0.77-1.67)	0.531
2013-15	186,752	49	0.26 (0.19-0.35)	1.07 (0.72-1.60)	0.726
2014-16	183,096	55	0.30 (0.23-0.39)	1.23 (0.83-1.81)	0.296
2015-17	182,394	63	0.35 (0.27-0.44)	1.41 (0.97-2.06)	0.071
2016-18	182,489	69	0.38 (0.29-0.48)	1.55 (1.07-2.24)	0.020
2017-19	178,055	72	0.40 (0.32-0.51)	1.65 (1.15-2.38)	0.007

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

Recent reports on maternal mortality in Ireland and the UK have identified thrombosis/thromboembolism as a leading direct obstetric cause of maternal death.[16,17] At 0.40 per 1,000 maternities, the incidence of PE in Ireland was higher than the reported rate in the UK (0.14 per 1,000 maternities).[18] Notwithstanding, we believe the Irish rate reported here may represent an underestimate as many postnatal cases of PE will be unknown to maternity units because the women would present to general hospitals.

The NPEC Severe Maternal Morbidity Group have endeavoured to develop a methodology in order to capture and audit these cases of PE more accurately, however, it is proving difficult to achieve. Hospital In-Patient Enquiry (HIPE) data are also being reviewed. As part of the NPEC triennial topic-specific audit series (2017-2019), a detailed audit of women presenting to Irish maternity units with a diagnosis of PE during pregnancy or within 42 days of the pregnancy end was carried out. Findings from this audit will be presented in a future separate report in 2021.

16 O'Hare MF, et al. on behalf of MDE Ireland. Confidential Maternal Enquiry in Ireland, Data Brief No 3. Cork: MDE Ireland, November 2018.
17 Knight M, et al. (Eds.) on behalf of MBRRACEUK. Saving Lives, Improving Mothers' Care - Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2014-16. Oxford: National Perinatal Epidemiology Unit, University of Oxford 2018. Available at: https://www.npeu.ox.ac.uk/mbrrace-uk
18 Lawson B, et al. UKOSS Annual Report 2017. Oxford: National Perinatal Epidemiology Unit 2017

Trends in septicaemic shock

The reported incidence of septicaemic shock was low at the start of the SMM audit. Eight cases were reported in the first two years but sixteen were reported in 2013. Even then, the rate for 2011-2013 was just 0.12 per 1,000 maternities. This increased rapidly and the 80 cases reported in 2014-2016 gave a rate of 0.44 per 1,000, more than three times the rate reported for 2011-2013. The apparent increase in reported cases in this triennium may reflect an increased awareness of sepsis following the introduction of guidelines on sepsis and the implementation of the Irish Maternity Early Warning System.[19,20] Since then, the rate has decreased to 0.28 per 1,000 in 2017-2019 though this is still more than twice the rate reported for 2011-2013 (Table 9).

Table 9: Incidence of septicaemic shock in Ireland, 2011-2019

Triennium	Maternities	Septicaemic shock	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	24	0.12 (0.08-0.18)	1.00 (ref.)	---
2012-14	191,439	41	0.21 (0.15-0.29)	1.75 (1.06-2.90)	0.029
2013-15	186,752	68	0.36 (0.28-0.46)	2.98 (1.87-4.75)	<0.001
2014-16	183,096	80	0.44 (0.35-0.54)	3.58 (2.27-5.64)	<0.001
2015-17	182,394	71	0.39 (0.30-0.49)	3.19 (2.01-5.06)	<0.001
2016-18	182,489	59	0.32 (0.25-0.42)	2.65 (1.65-4.25)	<0.001
2017-19	178,055	50	0.28 (0.21-0.37)	2.30 (1.41-3.74)	<0.001

Note: Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios.

The frequency of the specific SMMs renal or liver dysfunction, peripartum hysterectomy, PE and septicaemic shock are relatively similar and the trend in their incidence by triennium is illustrated in Figure 3. Distinctive trends are evident for each of these SMMs. This includes the rise and recent levelling off of the reported incidence of renal or liver dysfunction, the steady rate of both peripartum hysterectomy and of PE in the early years of the national audit followed by the recent increase in both SMMs and the sharp increase in septicaemic shock reported at the start of the decade followed by a steady decrease.

19 https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/sepsismanagement.pdf
20 https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/imews-guidelines.pdf

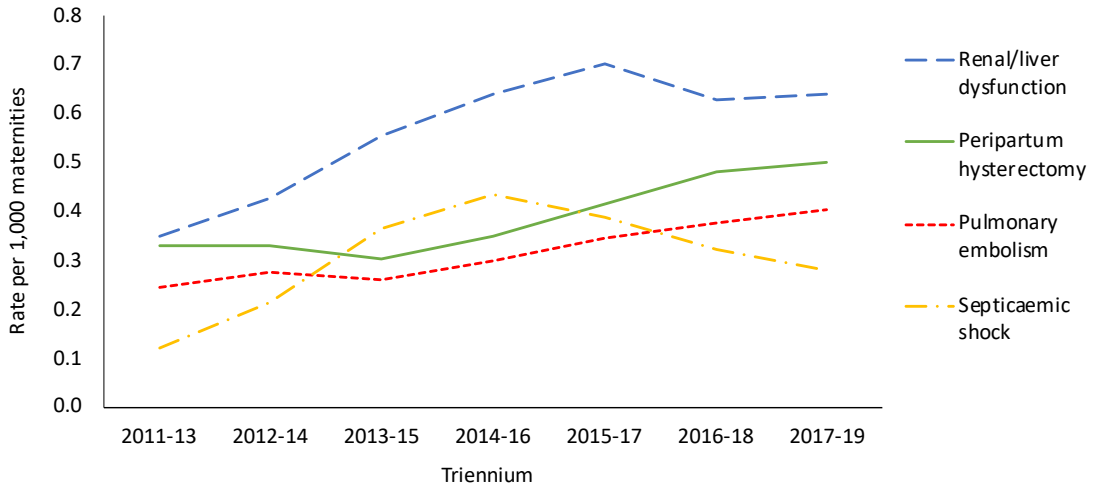


Figure 3: Trend in the rate of renal or liver dysfunction, peripartum hysterectomy, pulmonary embolism and septicaemic shock, 2011-2019

Eclampsia, uterine rupture and intervention radiology

Trends over time cannot be assessed for the incidence of eclampsia, uterine rupture and intervention radiology given the relatively small number of cases, on average of 7-10 per year of each SMM. However, based on the most recent five-year period, 2015-2019, from a total of 299,969 maternities in the participating maternity units, 52 cases of eclampsia, 47 cases of uterine rupture and 37 cases of intervention radiology were reported. This gives a rate of eclampsia of 0.17 per 1,000 maternities, which is lower than reported for the UK (0.27 per 1,000 maternities) and Netherlands (0.54 per 1,000 maternities).[21] The Irish rate of uterine rupture for 2015-2019 was 0.16 per 1,000. This is low considering that a recent study of nine European countries reported national rates ranging from 0.16 to 0.78 per 1,000 deliveries.[22]

21 Schaap, T. P., et al. (2014). Eclampsia, a comparison within the International Network of Obstetric Survey Systems. *Bjog, 121*(12), 1521-1528.
22 Vandenberghe, G., et al. The INOSS study of uterine rupture: a descriptive multi country population based study. BJOG: Int J Obstet Gy. 2019;126:370–381.

Ten Group Classification System

The Ten Group Classification System (TGCS) is a method of providing a common starting point for further detailed analysis within which all perinatal outcomes can be measured and compared.[23] The system classifies all pregnant women into one of 10 groups that are mutually exclusive and, as a set, totally comprehensive (see Appendix F).[24] The groups are based on five basic obstetric characteristics that are routinely collected for all maternities: parity, gestational age, onset of labour, fetal presentation and number of fetuses.

Seventeen of the 19 maternity units that participated in the SMM audit also classified their maternities according to the Robson TGCS (Appendix F). The 52,681 women who gave birth in these units accounted for 91% of the 57,983 women who gave birth in all 19 maternity units in Ireland. The incidence of MOH (due to an estimated blood loss of ≥2,500ml and/or a transfusion of five or more units of blood) in the 17 maternity units that submitted TGCS data are detailed in Table 10.

For the 17 units, the MOH rate was 3.09 per 1,000 maternities. Notwithstanding the relatively small numbers involved when examined by TGCS, there was striking evidence of increased risk of MOH in Group 8 (women with multiple pregnancies), in Group 9 (women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars) and in Group 10 (all singleton, cephalic, <36/40, including previous CS). However, while having a high rate, Groups 8-10 account for a small number of the total recorded MOH cases with only 36 cases recorded in these groups in contrast to 62 cases for the nulliparous cephalic groups (Group 1 and 2).

Table 10: Incidence of major obstetric haemorrhage (MOH) by the Ten Group Classification System (TGCS) in 17 Irish maternity units, 2019

Group	Group description	Maternities	Delivered by CS		MOH
		N	%	n	Rate (95% CI)
All		**52,681**	**34.1**	**163**	**3.09 (2.64-3.61)**
1	Nulliparous, singleton, cephalic, >37/40, spontaneous labour	8,438	13.8	28	3.32 (2.21-4.80)
2	Nulliparous, singleton, cephalic, >37/40 induced or elective CS	9,869	44.7	34	3.45 (2.39-4.81)
3	Multiparous (excluding previous CS), singleton, cephalic, >37/40, spontaneous labour	11,655	2.2	16	1.37 (0.78-2.23)
4	Multiparous (excluding previous CS), singleton, cephalic, >37/40 induced or elective CS	8,789	15.6	21	2.39 (1.48-3.65)
5	Previous CS, singleton, cephalic, >37/40, induced or elective CS	8,273	82.7	22	2.66 (1.67-4.03)
6	All nulliparous women with a single breech pregnancy	1094	94.9	2	1.83 (0.22-6.60)
7	All multiparous breech (including previous CS)	1200	78.3	4	3.33 (0.91-8.53)
8	All multiple pregnancies (including previous CS)	968	71.1	16	16.53 (9.45-26.84)
9	All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars	237	100.0	5	21.10 (6.85-49.23)
10	All singleton, cephalic, <36/40 (including previous CS)	2,250	45.1	15	6.67 (3.73-11.00)

Note: Rate per 1,000 maternities. CI=95% confidence interval. Exact Poisson 95% confidence intervals were calculated. CS=Caesarean section; TGCS Group could not be determined for 15 women.

23 Robson M et al. The 10-Group Classification System (Robson classification), induction of labor, and cesarean delivery. International Journal of Gynecology and Obstetrics 131 (2015) S23–S27

24 Robson MS (2001). Classification of caesarean sections. Fetal and Maternal Medicine Review, 12, pp 23-39 doi:10.1017/S0965539501000122.

Variation in rates by maternity unit

Variation in the 2019 SMM rate across the 19 Irish maternity units is illustrated in the funnel plot in Figure 4. The solid line represents the national SMM rate of 6.47 per 1,000 maternities. The dashed curves represent the limits within which 95% of units are expected to lie (i.e. within two standard deviations). The solid curves represent the limits within which 99.8% of units are expected to lie (i.e. within three standard deviations). These limits are adjusted according to the number of maternities at each unit and are wider for smaller units reflecting the greater volatility in rates based on small numbers. Regarding the 95% confidence limits, we can expect, on average, one in twenty units to have a rate outside the dashed lines. A diagrammatic aid outlining the interpretation of a funnel plot is detailed in the methods section of this report (Figure IV; page 23). Differences in rates between units must be interpreted with caution as they may not reflect care given but could reflect differences in levels of reporting and/or differences in the risk profile of the pregnant women presenting to the units.

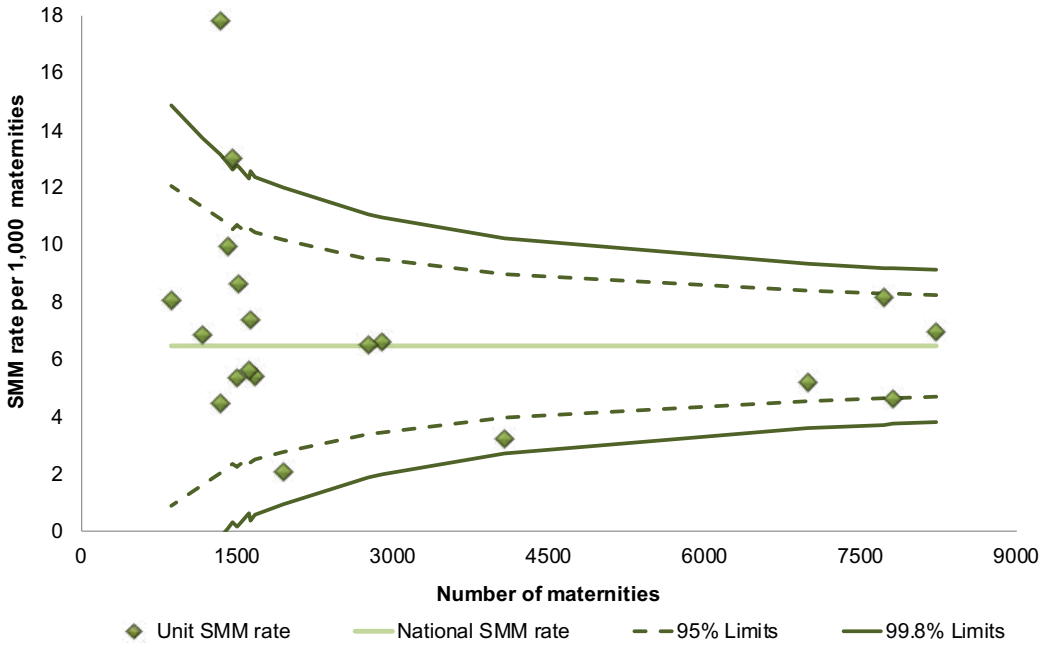


Figure 4: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit, 2019

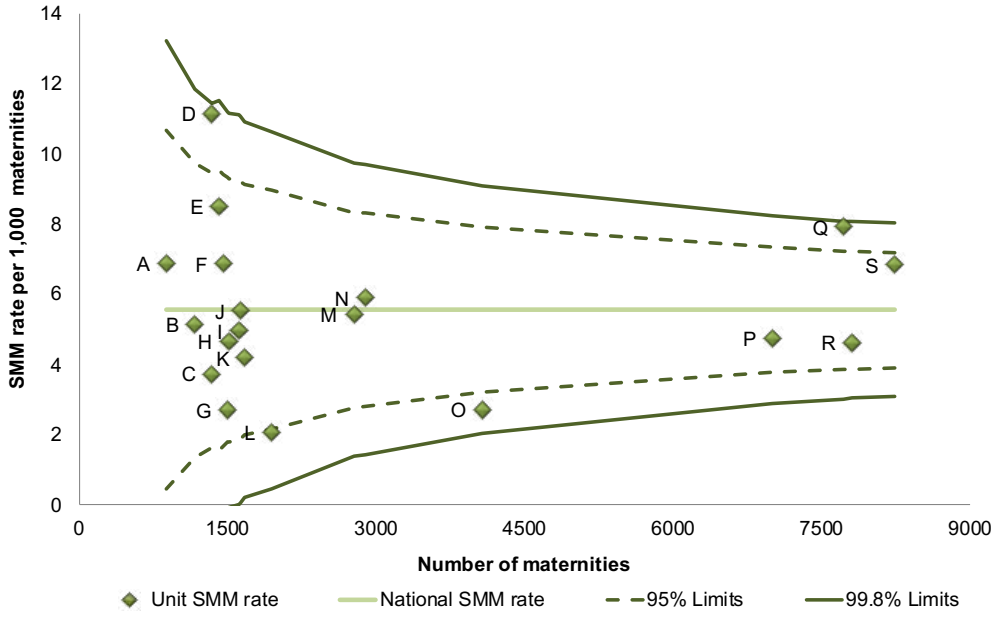
From Figure 4, it can be seen that two units had an SMM rate above the 99.8% upper limit, one just above it and one far above it with a rate that was almost three-times the national rate (17.80 vs. 6.47 per 1,000 maternities).

Of the SMM cases reported by the two outlying units with high rates, a high proportion (38% and 47%) were reported because they met the SMM criterion of being admitted to an ICU/CCU with no other SMM experienced as defined in this audit. In general, these were cases requiring monitoring above normal ward standard which could only be achieved by admission to the ICU/CCU.
It can also be seen from Figure 4 that two of the country's maternity units had an SMM rate between the lower 95% and the lower 99.8% limit, at 2.05 and 3.19 per 1,000 maternities. These two units reported four and 13 SMM cases for 2019 whereas the national rate would indicate that 13 and 26 SMM cases would have been expected in these units, respectively.

The funnel plot in Figure 5 illustrates the variation in the SMM rate by maternity unit after exclusion of the 53 cases admitted to an ICU/CCU with no other SMM experienced as defined in this audit. Variation in SMM rate across the maternity units was reduced after this adjustment. The adjusted national SMM rate was 5.55 per 1,000 maternities. The plot shows that no units had an adjusted SMM rate outside

the 99.8% limits, two units had a rate between the upper 95% and 99.8% limits and two units had a rate between the lower 95% and 99.8% limits.

Of the two units with a rate between upper 95% and 99.8% limits, only one unit was in this range for 2018, thus meeting the criteria for the National Office of Clinical Audit (NOCA) escalation process which defines a statistical outlier as results that fall "two standard deviations on or above the expected value across two consecutive reporting periods".[25] In line with the NOCA escalation policy, senior management in this unit has been informed that it is a statistical outlier for both SMM and MOH. Data quality has been confirmed with the unit's data coordinators and senior management have been requested to complete a review and analysis of SMM and MOH in their unit.



A - South Tipperary (STGH);	F – Portlaoise (MRHP);	K – Waterford (UHW);	P – Cork (CUMH);
B – Kerry (UHK);	G – Mayo (MUH);	L – Mullingar (RHM);	Q – Coombe (CWIUH);
C – Cavan (CGH);	H – Portiuncula (PUH);	M – Galway (UHG);	R - National Maternity (NMH);
D – Sligo (SUH);	I – Letterkenny (LUH);	N – Drogheda (OLOL);	S – Rotunda (RH).
E – Kilkenny (SLHK);	J – Wexford (WGH);	O – Limerick (UMHL);	

* Please see full hospital names in Appendix H

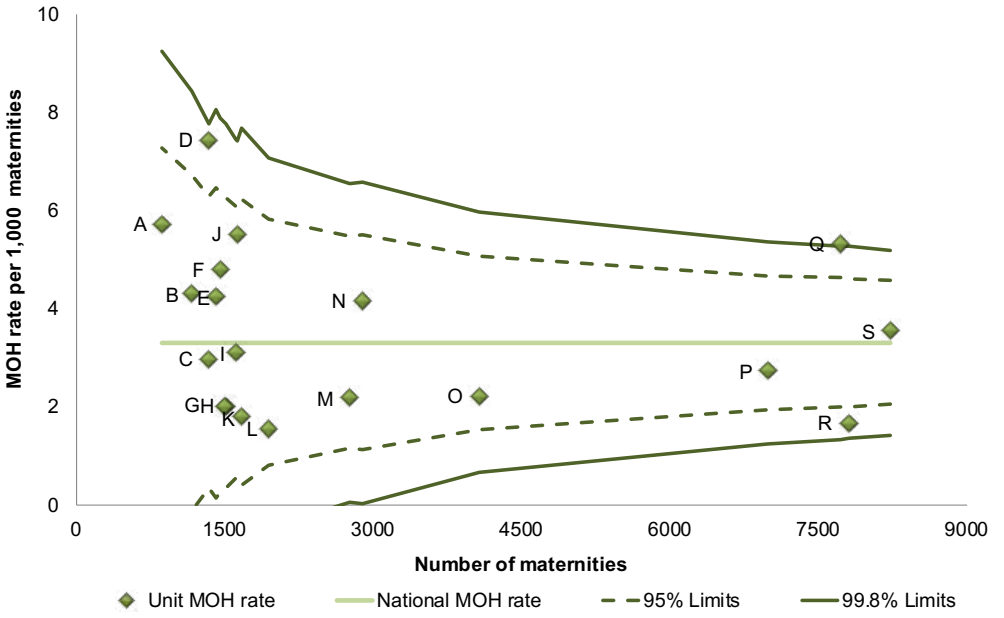
Figure 5: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit excluding cases admitted to an ICU/CCU with no other SMM experienced as defined in this audit, 2019

Figure 6 illustrates the variation across the country's 19 maternity units in the rate of MOH due to an estimated blood loss of at least 2,500ml and/or a transfusion of five or more units of blood. One maternity hospital had an MOH rate just above the 99.8% upper limit. The MOH rate for this hospital, 5.31 per 1,000 maternities, was 60% higher than the national rate of 3.31 per 1,000. As previously discussed, senior management in this hospital has been informed it is a statistical outlier for both SMM and MOH, and the NOCA escalation policy has been initiated. A second maternity hospital had an MOH rate between the lower 95% and 99.8% limits. The MOH rate for this hospital, 1.67 per 1,000, was approximately half the national rate. The hospital reported 13 MOH cases. The expected number based on the national MOH rate was 26.

Variances in rates of MOH between units may reflect variances in practices of estimating blood loss. The NPEC have previously recommended that a quantitative approach, involving volume and weight assessment to estimate blood loss, should be considered for use in all maternity units and that development of a national tool-kit would assist standardisation of such an

25 National Office of Clinical Audit (NOCA) Monitoring and escalation policy 2017. Available at: Available at: http://s3-eu-west-1.amazonaws.com/noca-uploads/general/NOCA-GEN-POL014_-_NOCA_-_Monitoring_Escalation_Policy_v2.1.pdf

approach.[26,27] These recommendations are being addressed by the National Women and Infant Health Programme. While no one tool may be completely accurate in estimating blood loss, a standard quantitative approach should facilitate a less variable assessment of blood loss.



A - South Tipperary (STGH);	F – Portlaoise (MRHP);	K – Waterford (UHW);	P – Cork (CUMH);
B – Kerry (UHK);	G – Mayo (MUH);	L – Mullingar (RHM);	Q – Coombe (CWIUH);
C – Cavan (CGH);	H – Portiuncula (PUH);	M – Galway (UHG);	R - National Maternity (NMH);
D – Sligo (SUH);	I – Letterkenny (LUH);	N – Drogheda (OLOL);	S – Rotunda (RH).
E – Kilkenny (SLHK);	J – Wexford (WGH);	O – Limerick (UMHL);	

* Please see full hospital names in Appendix H

Figure 6: Funnel plot of the rate of major obstetric haemorrhage (MOH) by maternity unit, 2019

26 Manning E, Leitao S, Corcoran P, McKernan J, de Foubert P, Greene RA, on behalf of the Severe Maternal Morbidity Group. Severe Maternal Morbidity in Ireland Annual Report 2016. Cork: National Perinatal Epidemiology Centre, 2018

27 Leitao S, Manning E, Corcoran P, Greene RA on behalf of the Severe Maternal Morbidity Group. Severe Maternal Morbidity in Ireland Annual Report 2017. Cork: 2019.

Maternal characteristics

Age

Maternal age was recorded for all of the 375 cases of severe maternal morbidity (SMM) in 2019 and ranged from 16 to 51 years (mean=33.5 years, SD=5.8 years). The age distribution of women who experienced SMM in 2016-2019 is detailed in Table 11. In 2019, their age profile was broadly similar to the population of women who gave birth. The exceptions were women aged 30-34 years who were under-represented among those who experienced SMM (28.8% vs. 34.2%) and women aged at least 40 years who were over-represented (14.4% vs.7.8%).

Table 11: Age distribution of women who experienced severe maternal morbidity (SMM), 2016-2019

Age group	SMM 2016* (N=405)	SMM 2017 (N=391)	SMM 2018 (N=401)	SMM 2019 (N=375)	All maternities 2019
<20yrs	7(1.7)	7(1.8)	7(1.7)	5(1.3)	1.5%
20-24yrs	24(5.9)	39(10)	30(7.5)	22(5.9)	8.0%
<25yrs**	31 (7.6)	46 (11.8)	37 (9.2)	27 (7.2)	9.5%
25-29yrs	63(15.6)	57(14.6)	47(11.7)	66(17.6)	17.0%
30-34yrs	141(34.8)	139(35.5)	123(30.6)	108(28.8)	34.2%
35-39yrs	134(33.1)	108(27.6)	137(34.1)	120(32.0)	31.5%
≥40yrs	36(8.9)	41(10.5)	57(14.2)	54(14.4)	7.8%

Note: Values are shown as n (%) unless otherwise stated. * Maternal age was not known for one woman 2016. ** represents the sum of the data detailed in the two rows above (<20yrs and 20-24yrs).

Previous pregnancy

Previous early pregnancy loss was reported for one-third of the women who experienced SMM in 2019 (33.6%, 126 of 375). Thirteen (3.5%) of these women had previously experienced three or more pregnancies that ended before 24 weeks of gestation.

Fourty-two per cent (n=159) of the women who experienced an SMM in 2019 were nulliparous which is similar to previous years (Table 12). Women with one previous completed pregnancies were under-represented among SMM cases relative to the population of women who gave birth in hospital in 2019 (27% vs. 35%) whereas women with at least three previous completed pregnancies were over-represented among those who experienced SMM (15% vs. 9%).

Table 12: Parity for women who experienced severe maternal morbidity (SMM), 2016-2019

Parity	SMM 2016 (N=403)*	SMM 2017 (N=389)*	SMM 2018 (N=401)	SMM 2019 (N=375)	All maternities 2019**
Nulliparous	183(45.4)	175(45.0)	152(37.9)	159(42.4)	39.2%
Para 1	108(26.8)	107(27.5)	113(28.2)	102(27.2)	34.6%
Para 2	73(18.1)	61(15.7)	72(18.0)	59(15.7)	17.3%
Para 3+	39(9.7)	46(11.8)	64(16.0)	55(14.7)	8.9%

Note: Values are shown as n (%) unless otherwise stated; *Parity was not known for one, three and two cases in 2016 and 2017, respectively. ** Data for all women who gave birth in hospital, according to Hospital In-Patient Enquiry (HIPE) data.

Age and Parity

Below the risk of SMM is examined separately by age and parity. Then both factors are considered together to assess their mutually independent influence on the risk of SMM. Risk of SMM was broadly similar for women under 40 years of age but risk was more than doubled among women aged at least 40 years (Table 13). Regarding parity, risk of SMM was lowest among women who had had one previous completed pregnancy. It was higher among nulliparous women but risk of SMM was twice as high among women with three or more previous pregnancies. The unadjusted and adjusted rate ratios in Table 13 were very similar, indicating that maternal age and parity operate as independent risk factors for SMM.

Table 13: Risk of severe maternal morbidity (SMM) by age and parity, 2019

		SMM rate (95% CI)	Unadjusted rate ratio (95% CI)	Adjusted rate ratio (95% CI)
Age group	**<25yrs**	4.90(3.23-7.13)	1.00 (Ref.)	1.00 (Ref.)
	25-29yrs	6.70(5.18-8.53)	1.37(0.87-2.14)	1.41(0.90-2.20)
	30-34yrs	5.45(4.47-6.58)	1.11(0.73-1.69)	1.15(0.75-1.76)
	35-39yrs	6.58(5.45-7.87)	1.34(0.88-2.04)	1.42(0.92-2.17)
	≥40yrs	11.99(9.01-15.65)	2.45(1.54-3.88)	2.49(1.55-3.99)
Parity	**Nulliparous**	7.00(5.96-8.18)	1.38(1.07-1.76)	1.45(1.13-1.86)
	Para 1	5.09(4.15-6.18)	1.00 (Ref.)	1.00 (Ref.)
	Para 2	5.87(4.47-7.58)	1.15(0.84-1.59)	1.10(0.80-1.52)
	Para 3+	10.70(8.06-13.93)	2.10(1.51-2.92)	1.93(1.39-2.69)

Note: SMM rate per 1,000 women who gave birth in hospital. Number of women who gave birth in hospital by age and parity was derived from Hospital In-Patient Enquiry (HIPE) data. Exact Poisson 95% confidence intervals were calculated for the rate and rate ratio. Ref. = Reference group.

Ethnicity

There are no national data available on ethnicity for the pregnant population in Ireland which impedes the calculation of SMM risk per ethnic group. The distribution by ethnic group of the women who experienced SMM in 2019 broadly reflected that of the general population of women aged 15-49 years as reported from the most proximal national census (Table 14).[28] In those who experienced SMM there was a slight over-representation of women whose ethnicity was described as Asian as they made up 7.2% of SMM cases compared to 2.7% of the population aged 15-49 years in this ethnic group. Similarly, women of Black ethnicity (2.7%) and women who defined themselves as Irish Traveller (3.7%) were over-represented in experiencing SMM when compared to the percentage of women aged 15-49 years of that ethnicity in the Irish population.

28 Central Statistics Office. (2018). Census 2016.

Table 14: Ethnicity of women who experienced severe maternal morbidity (SMM), 2019

	SMM 2019 (N=375)	15-49-year-old female population, 2016* %
White Irish	264(70.4)	77.1
Irish Traveller	14(3.7)	0.7
Other white background	47(12.5)	13.3
Asian/Asian Irish	27(7.2)	2.7
Black/Black Irish	10(2.7)	1.6
Other/mixed	7(1.9)	1.8
Not recorded	6(1.6)	2.7

Note: Values are shown as n (%) unless otherwise stated. *Central Statistics Office. (2018). Census of 2016.

Body mass index

Body mass index (BMI) for the women who experienced SMM in 2019 ranged from 16.7 to 57.4 kg/m^2. BMI was not known for 22 (5.9%) of the women. This represents an increase in the level of reporting of BMI (94.1% in 2019) when compared with SMM cases in 2018 (82.3%), and a similar level of reporting of BMI compared to 2017 (94.1%) and 2016 (91.6%).

Approximately 41% of the women who experienced SMM in 2019 had a BMI in the healthy range (n=143, 40.5%), 32.9% were overweight and 24.9% were obese (Table 15). In comparison to 2018 SMM data, this represented a slight decrease in the proportion of women experiencing a SMM who were overweight (from 36.9% in 2018 to 32.9% in 2019) and in the number of women who were obese (from 26.4% in 2018 to 24.9%) with an increase in women in the healthy category (from 36.4% in 2018 to 40.5% in 2019). The values recorded for 2019 are in line with those from previous years (2016 and 2017, Table 15).

It was also observed that of the total number of women experiencing two SMMs or more in 2019, a higher proportion were classified as obese (60.9% of the women of had two SMMs, 69.6% of the women experiencing three SMMs and 50% of those with four SMMs).

As shown in Table 15, women in the healthy BMI category were underrepresented among SMM cases and women in the obese category were overrepresented relative to the population of women who gave birth in 2019. This was reflected in their SMM rate of 5.12 and 7.79 per 1,000 for healthy and obese women, respectively. Thus, obese women had a 52% higher risk of SMM compared to women with a healthy BMI.

Table 15: Risk of severe maternal morbidity (SMM) by body mass index (BMI), 2019

BMI category (kg/m^2)	Maternities	SMM cases (N=353) *	SMM rate (95% CI)	Rate ratio (95% CI)
Underweight (<18.5)	844(1.5%)	6(1.7%)	7.11(2.61-15.47)	1.39(0.61-3.14)
Healthy (18.5-24.9)	27,919(48.2%)	143(40.5%)	5.12(4.32-6.03)	1.00(ref.)
Overweight (25.0-29.9)	17,924(30.9%)	116(32.9%)	6.47(5.35-7.76)	1.26(0.99-1.61)
Obese (≥30.0)	11,296(19.5%)	88(24.9%)	7.79(6.25-9.60)	1.52(1.17-1.98)

Note: * BMI was not known for 22 women who experienced SMM in 2019. Data on maternities by BMI were obtained for 31,476 women who gave birth or booked to give birth in one of the country's four large maternity hospitals. This is 54.3% of the 57,983 women who gave birth in hospital in 2019, according to HIPE data. We multiplied the BMI data on 31,476 women by 1.84 (i.e. 100%/54.3%) in order to estimate the national number of maternities by BMI category.

Table 16 details the percentage of women experiencing specific SMMs who were categorised as either overweight or obese. High BMI has been associated with maternal mortality and morbidity, in particular, morbidities such as pulmonary embolism, kidney disease and complications of anaesthetics.[29,30,31,32] As shown in Table 16, among those who had specific SMMs, women with high BMI were largely over-represented in the group of those affected by major obstetric haemorrhage (MOH), pulmonary embolism, uterine rupture and renal or liver dysfunction.

Table 16: Proportion of women with higher Body Mass Index (BMI) who experienced severe maternal morbidity (SMM), 2019

Morbidity	Women with high BMI* n(%)	Women with lower BMI** n(%)
Major obstetric haemorrhage	111(60.7)	72(39.3)
Peripartum hysterectomy	15(57.7)	11(42.3)
Pulmonary embolism	17(63.0)	10(37.0)
ICU/coronary care unit admission	63(56.3)	49(43.8)
Uterine rupture	3(30.0)	7(70.0)
Eclampsia	1(25.0)	3(75.0)
Septicaemic shock	8(53.3)	7(46.7)
Renal or liver dysfunction	22(68.8)	10(31.3)

Note: N=353, total number of women with information on BMI. *High BMI = BMI in the category overweight (25.0-29.9) and obese (≥30.0); **Lower BMI = BMI in the category underweight (<18.5) or healthy (18.5-24.9).

Smoking, alcohol and drug misuse

Smoking status at the time of the first hospital booking appointment was known for 91.2% of the 375 women. Of these, 9.1% (n=34 of 375) were reported to have been smoking at the time of the first booking. The prevalence of smoking during pregnancy is not routinely published for all Irish pregnancies but rates of 12%, 14%, 17% and 16% have been reported for England, Northern Ireland, Wales and Scotland, respectively.[33]

The quantity smoked was recorded for 30 of the 34 women who were smokers at the time of the first hospital booking appointment. Most commonly, these women smoked 5 or 10 cigarettes per day (range: 2-20 cigarettes/day). Of these 34 women, five were reported to have given up smoking during pregnancy (n=5 of 25, 26.5%, unknown for nine women).

Alcohol drinking status at the time of the first hospital booking appointment was not known for 25.1% of the women (n=94). Of the 281 women with available data, only 1.8% (n=5) self-reported to be drinking alcohol when they presented for their first booking appointment.

Five women were recorded as having a documented history of drug abuse or attendance at a drug rehabilitation unit prior to the pregnancy (1.3%, n=5 of 374, unknown for one case). Two additional women were reported as using drugs during the pregnancy (n=2 of 374, 0.5%).

29 Rosenberg E, Sergienko R, Abu-Ghanem S, Wiznitzer A, Romanowsky I, Neulander EZ, Sheiner E. Nephrolithiasis during pregnancy: characteristics, complications, and pregnancy outcome. World journal of urology. 2011 Dec 1;29(6):743-7.
30 Knight M, UKOSS. Antenatal pulmonary embolism: risk factors, management and outcomes. BJOG 2008; 115 (4):453-461
31 Malinowski AK, Bomba-Opoń D et al. Venous thromboembolism in obese pregnant women: approach to diagnosis and management. Polish Gynaecology 2017; vol. 88, Issue 8: 453–459
32 Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. BJOG; 2017, vol 124, Issue 9: 1374-1381
33 Euro-Peristat Project. European Perinatal Health Report. Core indicators of the health and care of pregnant women and babies in Europe in 2015. November 2018. Available www.europeristat.com

Recommendation:

- Internationally, social inequalities have been shown to impact on risk of SMM. There is a need to establish the evidence in this regard in Ireland. This requires improved maternity data at national level and more research in order to establish this evidence.

Recommendation:

- A **public health education programme on maternal morbidity and modifiable risk factors** should be developed.

Recommendation:

- Maternal and Newborn Clinical Management System (MN_CMS) data from Irish maternity units should be collated to identify the influence of risk factors for SMM in Ireland including: ethnicity, maternal age, BMI, smoking, alcohol consumption and employment status. This should overcome the current deficit in the pregnant population data.

Obstetric factors associated with the severe maternal morbidity event

For 9.5% of the women who experienced SMM in 2019, their pregnancy was the result of infertility treatment (n=34 of 358, 9.5%; unknown for 17 women). In the majority of these cases the method of infertility treatment was in vitro fertilisation (n=29, 85.3%; unknown method for one woman). Other methods reported include Clomid (n=2) and intrauterine insemination (n=2).

The prevalence of a previous caesarean section was nearly 30% among the women who had previously given birth (n=108 of 375, 28.8%).

Gestation at pregnancy-end for women who experienced a SMM ranged from 4 to 42 weeks. For over 60% of the women affected, their pregnancy went full term (n=253, 67.5%) (Table 17). For a further 18.4% of women, their pregnancy ended at moderate-to-late pre-term gestation (32-36 weeks), whereas for 6.4%, the end of pregnancy occurred before 22 weeks of gestation. There was a notable increase in the latter group as the percentage of women experiencing an SMM following pregnancy-end at 22 weeks nearly doubled (Table 17).

Table 17: Gestation at pregnancy-end for women who experienced severe maternal morbidity, 2016-2019

	2016 (N=399)*	2017 (N=386)*	2018 (N=398)*	2019 (N= 375)*
Pre-viable (<22wks)	16(4.0)	12(3.1)	15(3.7)	24(6.4)
Extremely pre-term (22-27wks)	9(2.3)	11(2.8)	9(2.3)	10(2.7)
Very pre-term (28-31wks)	18(4.5)	33(8.5)	26(6.5)	16(4.3)
Moderate/late pre-term (32-36wks)	83(20.8)	99(25.6)	77(19.3)	69(18.4)
Term (37-41wks)	271(67.9)	228(59.1)	267(67.1)	253(67.5)
Post-term (42wks+)	2(0.5)	3(0.8)	4(1)	3(0.8)

Note: Values are shown as n (%) unless otherwise stated; * Gestation was not known for seven, five and three cases in 2016, 2017 and 2018 respectively.

Severe maternal morbidity associated with early pregnancy loss

Early pregnancy loss (i.e. before 24 weeks of gestation and birthweight less than 500g) was experienced by 24 of the 374 women (6.4%, unknown for one woman). Sixteen women (4.3%) experienced a miscarriage and eight (2.1%) women experienced an ectopic pregnancy.

Thirteen of the early pregnancy losses were diagnosed with one SMM (11 miscarriages and two ectopic pregnancies) and eight women were diagnosed with two SMMs (three miscarriages and five ectopic pregnancy). A further three women were diagnosed with three SMMs (two miscarriages and one ectopic pregnancy).

MOH was the most frequently reported SMM associated with 13 cases of early pregnancy loss (nine miscarriages and four ectopic pregnancies). Of these 13 MOH cases, two women had a ruptured ectopic pregnancy.

Among the women experiencing early pregnancy loss, two were complex cases of septic shock, two had a pulmonary embolism, two were associated with acute respiratory dysfunction and one was diagnosed with eclampsia. Nine women met the criteria for admission to ICU, of these, three women were admitted due to complications related to MOH.

Severe maternal morbidity associated with multiple pregnancy

A total of 350 women had an SMM which was not associated with early pregnancy loss. As shown in Table 18, 19 of these women had a multiple birth (n=19 of 350, 5.4%). All of the multiple births were twins. In Ireland in 2019, 1.9% of all women delivering had a multiple birth (n=1,083 of 57,983). This indicates that multiple pregnancy was almost three times more common in cases of SMM than in all maternities (5.4% versus 1.9%), a reflection of the increased risk of SMM associated with multiple pregnancy. The national SMM rate associated with singleton pregnancy was 5.82 per 1,000 maternities in 2019 whereas the SMM rate associated with multiple pregnancy was three times higher at 17.54 per 1,000 maternities, a highly statistically significant difference (p-value<0.001). These findings are similar to the most recent reports from Scotland where 6.4% of SMM cases with available data in 2012 were associated with twin pregnancies, four times higher than their proportion of twin births in 2012 (1.5%).[34]

34 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Table 18: Single and multiple births for women who experienced severe maternal morbidity (SMM) but who did not experience early pregnancy loss, 2016-2019

	SMM 2016 (N=385)	SMM 2017 (N=376)	SMM 2018 (N=388)	SMM 2019 (N=350)	All maternities 2019	SMM rate (95% CI)	Rate ratio (95% CI
Single	356(92.5)	344(91.5)	358(92.3)	331(94.6)	98.1%	5.82 (5.21-6.48)	1.00 (Ref.)
Multiple	29(7.5)	32(8.5)	30(7.7)	19(5.4)	1.9%	17.54 (10.56-27.40)	3.02 (1.90-4.79)

Note: Values are shown as n (%) unless otherwise stated. SMM rate per 1,000 maternities. Exact Poisson 95% confidence intervals were calculated for the rate and rate ratio. Ref.=Reference group.

Mode of delivery associated with severe maternal morbidity

The mode of delivery for two thirds of the 338 women whose SMMs were not associated with early pregnancy loss in 2019 was caesarean section (66.0%, unknown for 12; Table 19). The majority of caesarean sections in cases of SMM were carried out prior to labour which may reflect the clinical complexity of the pregnancy rather than indicating that mode of delivery may be influencing the risk of SMM. Approximately one in three women had a vaginal delivery (34.0%), usually spontaneously (22.9% of all deliveries).

Table 19: Primary mode of delivery (excluding those who experienced early pregnancy loss) for women who experienced severe maternal morbidity, 2016-2019

	2016 (N=383)*	2017 (N=375)*	2018 (N=383)*	2019 (N=338)*
Vaginal	**138(36)**	**120(32)**	**128(33.4)**	**115(34)**
Spontaneous	90(23.5)	74(19.7)	80(20.9)	77(22.8)
Assisted breech	0(0)	4(1.1)	3(0.8)	2(0.6)
Ventouse	30(7.8)	22(5.9)	26(6.8)	17(5)
Non-rotational forceps	14(3.7)	19(5.1)	15(3.9)	18(5.3)
Rotational forceps	4(1)	1(0.3)	4(1)	1(0.3)
Caesarean section	**245(64)**	**255(68)**	**255(66.6)**	**223(66)**
Elective LSCS (no labour)	55(14.4)	84(22.4)	83(21.7)	81(24)
Emergency LSCS (no labour)	101(26.4)	88(23.5)	83(21.7)	54(16)
Elective LSCS (labour)	7(1.8)	4(1.1)	5(1.3)	4(1.2)
Emergency LSCS (labour)	81(21.1)	77(20.5)	84(21.9)	79(23.4)
Classical	1(0.3)	2(0.5)	--	5(1.5)

Note: Data excludes 18, 12 (and 2 unknown), 14 and 24 (and one unknown) cases of early pregnancy loss in 2016, 2017, 2018 and 2019 respectively. Values shown are n (%) unless otherwise stated; * Mode of delivery was not known for three cases in 2016, two cases in 2017, five cases in 2018 and 12 cases in 2019. For cases of multiple births when the mode of delivery differed for the babies, the more complex mode of delivery was taken as the primary mode. LSCS=Lower segment caesarean section.

Recommendation

- **Antenatal education:**
  a) Antenatal education/information should be provided by the multidisciplinary team to women to ensure an understanding of maternal morbidity and complication awareness.

  b) When a pregnant woman is identified as high risk for significant morbidity, specific education should be available to her during antenatal birth preparation.

  c) The national standards on antenatal education should provide guidance on specific education for maternal morbidity awareness.

Maternal care details

The level of maternal care provided has been recorded since the 2014 SMM audit. Definitions for Level of Care are provided in Appendix I.

Virtually all of the women who experienced SMM in 2019 required an increased level of support/critical care (Table 20). Over half of the women required Level 1 care (52.5%) and 33.9% needed Level 2 Care. A further 8.8% of women experiencing an SMM required Level 3 Care.

Table 20: Level of maternal care provided to 375 women during clinical SMM events in Ireland, 2019

Level of Care	Definition	n(%)
Level 0: Normal ward care	Care of low-risk pregnant women	18(4.8)
Level 1: Additional monitoring or intervention, or step down from a higher level of care	Patients at risk of their condition deteriorating and needing a higher level of observation or those recently relocated from higher levels of care	197(52.5)
Level 2: Single organ support	Patients requiring invasive monitoring/ intervention including support for a single failing organ system (incl. use of arterial and CVP lines, excl. advanced respiratory support)	127(33.9)
Level 3: Advanced respiratory support alone, or support of two or more organ systems	Patients requiring advanced respiratory support (mechanical ventilation) alone or basic respiratory support along with the support of at least one additional organ	33(8.8)

Over 40% of the women admitted to an ICU/CCU required Level 2 Care (42.9%); 34.4% of the women admitted to ICU/CCU required Level 1 Care and 21.4% required Level 3 Care in 2019. This highlights that admission to an ICU/CCU does not infer that a woman has a requirement for Level 3 Care. As such it should be considered that within the Irish context, ICU/CCU admission may not be a proxy indicator for SMM. As previously mentioned, admissions to intensive care can reflect resource issues in cases where women required a higher level of monitoring in small maternity units without HDU facilities. Figure 7 details the ICU and HDU facilities available across maternity units in Ireland. Nearly half of the 53 women admitted to an ICU/CCU requiring Level 1 Care did not experience another SMM as defined by this audit (n=25, 47.2%) in 2019.

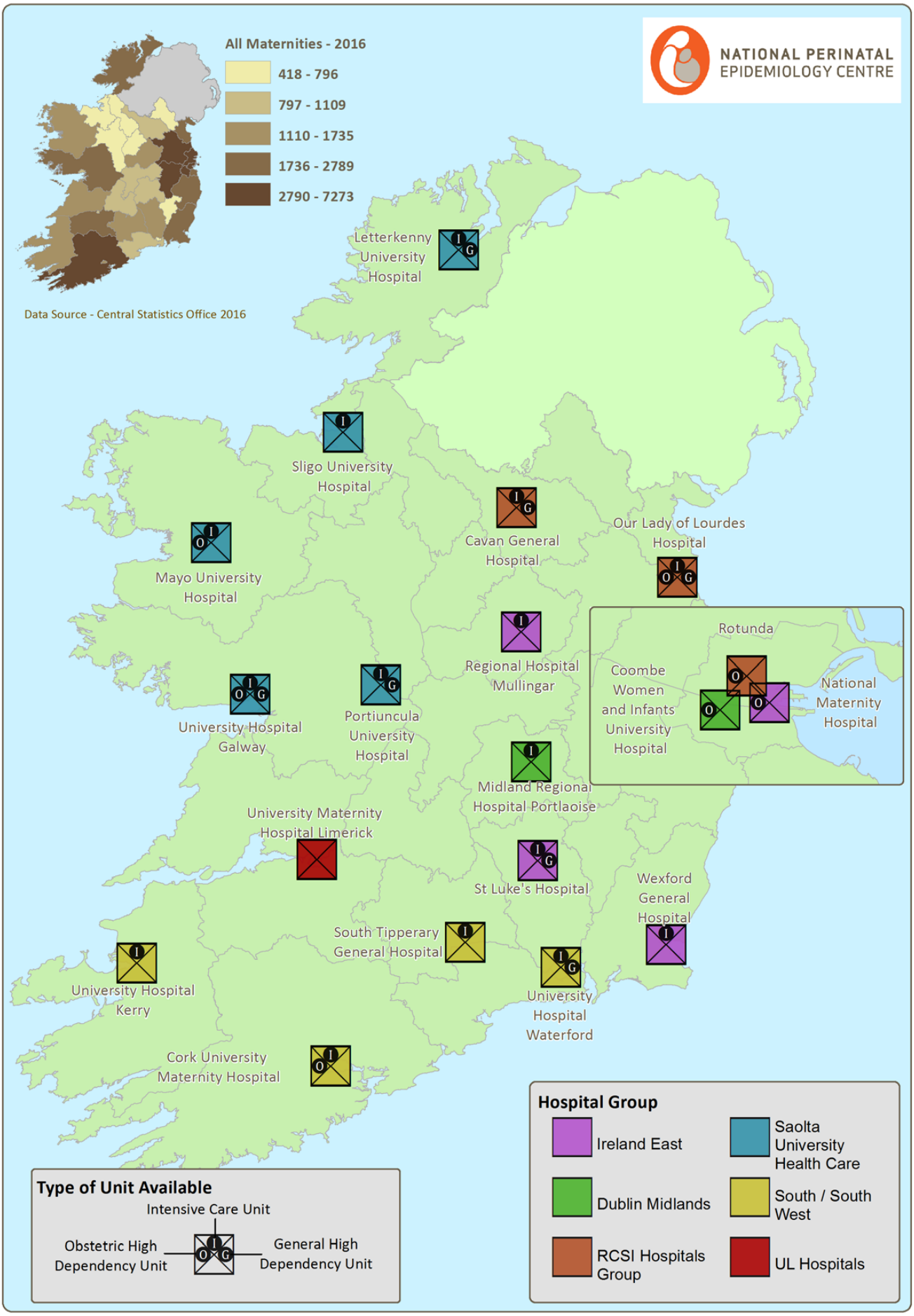


Figure 7: Map of maternity units and hospital groups in the Republic of Ireland according to the type of unit of care available in 2019

Of the major obstetric haemorrhage cases recorded in 2019, over half of these required Level 1 Care (57.3%) while 28.6% required Level 2 Care and 10.9% required Level 3 Care (Table 21). As expected clinically, higher levels of critical care/monitoring were required for the women experiencing life-threatening maternal morbidities, e.g. acute respiratory dysfunction and cardiac arrest.

Table 21: Level of maternal care provided to women during specific clinical severe maternal morbidity (SMM) events in Ireland, 2019

	Total (2019) N (%)	Level 0 n (%)	Level 1 n (%)	Level 2 n (%)	Level 3 n (%)
All SMM cases	375(100)	18(4.8)	197(52.5)	127(33.9)	33(8.8)
Major obstetric haemorrhage	192(51.2)	6(3.1)	110(57.3)	55(28.6)	21(10.9)
ICU/CCU admission	154(41.1)	2(1.3)	53(34.4)	66(42.9)	33(21.4)
Renal or liver dysfunction	33(8.8)	-	14(42.4)	17(51.5)	2(6.1)
Septicaemic shock	19(5.1)	-	7(36.8)	9(47.4)	3(15.8)
Peripartum hysterectomy	28(7.5)	-	13(46.4)	9(32.1)	6(21.4)
Pulmonary embolism	27(7.2)	7(25.9)	12(44.4)	5(18.5)	3(11.1)
Uterine rupture	10(2.7)	3(30)	5(50)	1(10)	1(10)
Pulmonary oedema	7(1.9)	-	3(42.9)	4(57.1)	-
Eclampsia	8(2.1)	-	3(37.5)	5(62.5)	-
Interventional radiology	14(3.7)	1(7.1)	6(42.9)	6(42.9)	1(7.1)
Acute respiratory dysfunction	7(1.9)	-	-	-	7(100)
Cerebrovascular event	4(1.1)	1(25)	-	2(50)	1(25)
Status epilepticus	-	-	-	-	-
Cardiac arrest	5(1.3)	-	-	1(20)	4(80)
Coma	-	-	-	-	-
Anaesthetic problem	6(1.6)	-	5(83.3)	-	1(16.7)

Note: % shown refers to level of care per each type of morbidity; ICU=intensive care unit; CCU=coronary care unit *more than one morbidity may apply per woman.

Neonatal outcomes

Of the 350 women whose SMM was not associated with early pregnancy loss, a total of 370 babies were delivered: 332 singleton births and 19 twin births (38 babies). Information on neonatal outcome, regarding perinatal death, was available for all of these infants. Of the 370 infants, there were 13 perinatal deaths: six stillbirths, four early neonatal deaths and three late neonatal deaths.

All of the 13 perinatal deaths occurred in singleton pregnancies. Six of the 13 perinatal deaths (46.1%) were born at a gestation between 22 and 27 weeks: two early neonatal death cases, two late neonatal death cases and two stillbirths. Four perinatal deaths (30.8%) occurred in babies born at 32-36 weeks of gestation: three neonatal deaths and one stillbirth. Additionally, for two stillbirths (15.4%), gestation was 28-31 weeks (very pre-term) and one baby (7.7%) was born stillborn at full-term (37-41 weeks).

Over two thirds of the 13 women affected by perinatal deaths experienced major obstetric haemorrhage (n=9, 69.2%), this represents an increase when compared to 2017 (33.3%) and 2018 (50%).

The mortality rate based on the six stillbirths and four early neonatal deaths among the 370 infants was 27.03 per 1,000 births, i.e. almost 3% or one in 35 of the infants died. This rate was 4.5 times the perinatal mortality rate observed for all births in Ireland in 2019 (p-value<0.001; Table 22). However, the rate is in line with the perinatal mortality rate among infants born to women with SMM in previous years in Ireland and over several years up to 2012 in Scotland, which ranged from 17 to 64 per 1,000 maternities.[35]

Table 22: Perinatal mortality among infants born to women with SMM in Ireland in 2019 compared to perinatal mortality among all infants born in Ireland

	Perinatal deaths	Births	PMR (95% CI)	Rate ratio (95% CI)
All births 2019*	357	59,083	6.04 (5.43-6.70)	1.00 (Ref.)
SMM 2018	10	370	27.03 (12.96-49.70)	4.47 (2.39-8.39)

Note: PMR=perinatal mortality rate per 1,000 births; * Data from: O'Farrell IB, Manning E, P Corcoran, Greene RA, on behalf of the Perinatal Mortality Group. Perinatal Mortality in Ireland Annual Report 2019. Cork: National Perinatal Epidemiology Centre, 2021. Poisson 95% confidence intervals were calculated for the rate and rate ratio. Ref. = Reference group.

Of the 351 live born infants with available information on neonatal outcome, 6.6% (n=23) were intubated following delivery in 2019 and half (n=175, 50%) were transferred to the Special Care Baby Unit (SCBU) or Neonatal Intensive Care Unit (NICU; Table 21).

Table 23: Selected neonatal outcomes in livebirths, 2019

	N=351*
Intubation following delivery	23(6.2)
Transfer to SBCU/NICU	175(47.6)

Note: SCBU=Special Care Baby Unit; NICU=Neonatal Intensive Care Unit.* N= total number of live births, neonatal outcome unknown for 1 baby.

35 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

In summary

The rate of severe maternal morbidity (SMM) in Ireland continues to increase, particularly the rate of major obstetric haemorrhage (MOH).

Risk of SMM was twice as high among women with three or more previous pregnancies. Multiple pregnancy was almost three times more common in cases of SMM than in all maternities.

Although increasing SMM rates may reflect complexity of the pregnant population, it also acts as a surrogate measure of quality of care in the maternity services. Further, increasing numbers of women, during or shortly after pregnancy, require higher Levels of Care. This highlights increasing demands on the maternity services.

Increasing national rates of MOH, and variations in rates of MOH between units, continues to be identified in this SMM audit. These issues have underscored recommendations in previous NPEC SMM reports. The development of a national quality improvement initiative to evaluate post-partum haemorrhage, in a joint NWIHP NPEC collaboration, highlights the value of on-going SMM audit in order to improve care of the women in the Irish maternity services.

The rate of peripartum hysterectomy (PH) has increased in recent years (2017-2019). Similar to National and International studies, this audit has identified the strong association between PH and morbidly adherent placenta (MAP). Research on the incidence and management of MAP in Ireland is warranted.

For the first time since the inception of this audit, hospitals are identified in funnel plots detailing SMM and MOH rates across units. This is a movement towards greater transparency in the Irish maternity services.

Appendix A: Hospital co-ordinators and contributors 2019

Hospital	Co-ordinators	Additional contributors
Cavan General Hospital	Dr Rukhsana Majeed,	Ms Karen Malocca
Coombe Women and Infants University Hospital	Ms Julie Sloan	Dr Bridgette Byrne and Dr Sharon Sheehan
Cork University Maternity Hospital	Ms Alex Campbell, Ms Denise Malone	Prof Richard Greene
University Hospital Kerry	Ms Mary Stack Courtney	Ms Sandra O Connor
Limerick University Maternity Hospital	Dr Mendinaro Imcha, Dr Nyan Chin, Ms Fiona Sampson	
Letterkenny University Hospital	Ms Mary Lynch	Ms Evelyn Smith
Mayo University Hospital, Castlebar	Ms Marcella Gavin, Ms Mary Devers and Ms Kathy Rava	Dr Hilary Ikele
Regional Hospital, Mullingar	Ms Marie Corbett	
Midland Regional Hospital, Portlaoise	Ms Ita Kinsella, Ms Emma Mullins	
National Maternity Hospital	Dr Mary Higgins	
Our Lady of Lourdes Hospital, Drogheda	Ms Siobhan Weldon	
Portiuncula University Hospital, Ballinasloe	Ms Melinda O'Rourke Ms Priscilla Neilan	
Rotunda Hospital, Dublin	Dr Sharon Cooley, Dr Khadeeja Alnasser	
Sligo University Hospital	Ms Madeleine Munnelly	Ms Juliana Henry
South Tipperary General Hospital	Ms Mary O' Donnell	
St Luke's Hospital, Kilkenny	Ms Fiona Dalton, Ms Anne Margaret Hogan	
University Hospital Galway	Ms Louise Fitzpatrick	
University Hospital Waterford	Ms Janet Murphy	
Wexford General Hospital	Ms Helen McLoughlin	

Appendix B: Maternal Morbidity Group Members

Dr. Bridgette Byrne, Consultant Obstetrician & Gynaecologist, Coombe Women & Infants University Hospital, Dublin.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Dr Sharon Cooley, Consultant Obstetrician & Gynaecologist, The Rotunda Hospital, Dublin.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Ms. Deirdre Daly, Lecturer in Midwifery, Trinity College Dublin. *Nominated by Deputy Nursing Services Director, HSE*

Ms Anne Fallon, Lecturer in the School of Nursing and Midwifery, National University of Ireland, Galway.

Dr Mary Higgins, Consultant Obstetrician & Gynaecologist, National Maternity Hospital, Holles Street, Dublin 2
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Ms Claire Jones, Patient Representative

Ms. Ita Kinsella, Clinical Midwife Manager 2, Midland Regional Hospital Portlaoise.

Ms. Janet Murphy, Advanced Midwife Practitioner, Waterford Regional Maternity Hospital.
Nominated by Deputy Nursing Services Director, HSE

Dr Meabh Ni Bhuinneain, Consultant Obstetrician & Gynaecologist, Mayo General Hospital, Castlebar, Co. Mayo
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Dr Cliona Murphy, Consultant Obstetrician & Gynaecologist, Coombe Women & Infants University Hospital, Dolphins Barn, Dublin 8
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Prof. Richard Greene, Consultant Obstetrician/Gynaecologist, Cork University Maternity Hospital Chair, Director of the National Perinatal Epidemiology Centre

Ms. Edel Manning, Research Midwife, National Perinatal Epidemiology Centre, Severe Maternal Morbidity Audit Project Manager

Mr. Paul Corcoran PhD, Epidemiologist, National Perinatal Epidemiology Centre

Appendix C: NPEC Governance Committee

Chair: Dr. Michael Robson, Consultant Obstetrician and Gynaecologist, National Maternity Hospital

Professor Tom Clarke, Consultant Neonatologist, Rotunda Hospital (Retired)

Dr Sharon Cooley, Institute of Obstetrics and Gynaecology Representative

Ms. Marie Cregan, Patient Representative, University College Cork

Professor Declan Devane, Chair of Midwifery, National University of Ireland, Galway

Dr. Geraldine Gaffney, Senior Lecturer, National University of Ireland, Galway

Professor Richard Greene, Consultant Obstetrician & Gynaecologist, Cork University Maternity Hospital, Director of the National Perinatal Epidemiology Centre

Professor Shane Higgins, Master, The National Maternity Hospital

Dr. Heather Langan, Consultant Obstetrician and Gynaecologist, Sligo General Hospital

Professor Fergal Malone, Master, The Rotunda Hospital

Professor Eleanor Molloy, Faculty of Paediatrics Representative

Ms. Connie McDonagh, Clinical Midwife Manager 3, St. Luke's General Hospital

Dr. Mary O'Mahony, Specialist in Public Health Medicine, HSE

Dr. Sharon Sheehan, Master, Coombe Woman and Infants University Hospital

Ms Collette Tully, NOCA Executive Director, National Office of Clinical Audit

Ms Ann O'Byrne, Chair of the national Designated Midwifery Officer Group - Home Births

Appendix D: National Office of Clinical Audit (NOCA) endorsement of the Severe Maternal Morbidity in Ireland Annual Report 2019

NOCA National Office of Clinical Audit

Prof Richard Greene,
Director,
National Perinatal Epidemiology Centre,
5th Floor, Cork University Maternity Hospital,
Wilton,
Cork.

26/02/2021

Dear Prof Greene,

I wish to acknowledge receipt of the Severe Maternal Morbidity in Ireland Annual Report 2019. Following your presentation to the NOCA Quality Assurance Committee on the 12th February, 2021 we are delighted to endorse this report.

On behalf of the NOCA Governance Board, I wish to congratulate you and your committee on an excellent report. Transparent public reporting is a cornerstone of a healthcare service focussed on patient safety and service improvement. This report provides assurance to all pregnant and recently pregnant women that their care is being carefully monitored in Irish maternity hospitals.

Please accept this as formal endorsement from the NOCA Governance Board.

Yours sincerely,

Dr Brian Creedon
Clinical Director
National Office of Clinical Audit

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Appendix E: NPEC Severe Maternal Morbidity Notification Form

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

CONFIDENTIAL AUDIT
OF
SEVERE MATERNAL MORBIDITY IN IRELAND

Notification Form: 2019

Hospital Name _____

Completed by _____
(Please print name and staff grade)

Date of clinical event: ☐☐/☐☐/☐☐

Time of onset of clinical event: ☐☐:☐☐

Woman's details:

Age ☐

Parity: ☐ + ☐
(Status prior to delivery)

Height at booking _____cm

Weight at booking _____kg

BMI ☐

Date of delivery: ☐☐/☐☐/☐☐
(or pregnancy end)

Gestation at delivery/pregnancy end ☐
(Completed weeks)

1a. Ethnic group: White Irish ☐ Irish Traveller ☐

Any other White background ☐ Please specify country of origin_____

Asian or Asian Irish ☐ Black or Black Irish ☐

Other, including mixed ethnic backgrounds: ☐ Not recorded ☐

1b. Was the care of this woman transferred from another hospital Yes ☐ No ☐

If yes please indicate timing of transfer in relation to pregnancy status:

Woman transferred with fetus in-utero ☐ Woman transferred following delivery of baby ☐

Name of referring maternity unit: _____

1

2a. Did the woman smoke at booking? Yes ☐ please specify quantity _____

No ☐ Not recorded ☐

2b. Did she give up smoking during pregnancy? Yes ☐ No ☐ Not recorded ☐ N/A ☐

3. Did the woman drink alcohol at booking? Yes ☐ .No ☐ Not recorded ☐

4. Is there documented history of drug abuse or attendance at a drug rehabilitation unit?

None recorded ☐ Prior to this pregnancy ☐ During this pregnancy ☐

5 Obstetric history: Did the woman have a previous caesarean section Yes ☐ No ☐

6. This Pregnancy

6 a. Was this pregnancy the result of infertility treatment? Yes ☐ No ☐ Unknown ☐

6 b. If yes please specify method of fertility treatment _____

7. Was this an early pregnancy loss? No ☐ Yes: Miscarriage ☐ Yes: Ectopic pregnancy ☐

If early pregnancy loss please go to question 10

8 Delivery Details

8a. Onset of Labour: Spontaneous ☐ Induced ☐ Never in labour ☐

8b. Lie of fetus at delivery Longitudinal ☐ Oblique ☐ Transverse ☐

8c. Presentation at delivery Cephalic ☐ Breech ☐ Other ☐

8d. Number of fetuses/babies in this delivery ☐

9. Mode of delivery:

	Baby 1	Baby 2*		Baby 1	Baby 2*
i) Spontaneous vaginal delivery	☐	☐	vi) Elective LSCS not in labour	☐	☐
ii) Assisted vaginal breech delivery	☐	☐	vii) Elective LSCS in labour	☐	☐
iii) Ventouse vaginal delivery	☐	☐	viii) Emergency LSCS not in labour	☐	☐
iv) Non-rotational forceps vaginal delivery	☐	☐	ix) Emergency LSCS in labour	☐	☐
v) Rotational forceps vaginal delivery	☐	☐	x) Classical Caesarean Section	☐	☐

2

10. Neonatal Outcome

Please answer **yes or no** as applicable

Baby Outcomes	Baby 1	Baby 2	Baby 3
Birth weight in grams			
Intubation following delivery			
Transferred to SBCU/NICU			
*Early Neonatal Death			
*Late Neonatal Death			
Intrauterine death ≥ 500g and/or ≥ 24 weeks gestation			

11.Maternal Care Details

11a. Location of Care during clinical event:

Please tick all that apply

On the ward ☐ Delivery Suite ☐ Theatre ☐ High dependency unit ☐ ICU/CCU ☐

11b. Level of Care Required:

Please indicate the **highest level** of care required during the clinical event:

Level of care	**Definition**	**Please tick one box**
Level 0: Normal ward care	Care of low risk pregnant women	
Level 1: Additional monitoring or intervention, or step down from higher level of care	Patients at risk of their condition deteriorating and needing a higher level of observation or those recently relocated from higher levels of care	
Level 2: Single Organ Support**	Patients requiring invasive monitoring/ intervention* including support for a single failing organ system (excluding advanced respiratory support).	
Level 3: Advanced respiratory support alone, or support of two or more organ systems**	Patients requiring advanced respiratory support (mechanical ventilation) alone or basic respiratory support along with support of at least one additional organ.	

*** invasive monitoring/intervention includes the use of arterial and CVP lines**
****Examples of level 2 and 3 care in the critically ill pregnant or recently pregnant woman are outlined below**

Level 2 examples
Basic Respiratory Support (BRS): 50% or more oxygen via face-mask to maintain oxygen saturation; Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP)
Basic Cardiovascular Support (BCVS): Intravenous anti-hypertensive, to control blood pressure in pre-eclampsia; Arterial line used for pressure monitoring or sampling; CVP line used for fluid management and CVP monitoring to guide therapy
Advanced Cardiovascular Support (ACVS): Simultaneous use of at least two intravenous, anti-arrhythmic/anti-hypertensive/vasoactive drugs, one of which must be a vasoactive drug; Need to measure and treat cardiac output
Neurological Support: Magnesium infusion to control seizures / prophylaxis of eclampsia in severe PET
Hepatic Support: Management of acute fulminant hepatic failure, e.g. from HELLP syndrome or acute fatty liver, such that transplantation is being considered

Level 3 examples
Advanced Respiratory Support: Invasive mechanical ventilation

Support of two or more organ systems: Renal support and BRS; BRS/BCVS and an additional organ supported; Intracranial pressure monitoring

Reference: Saravanakumar K, Davies L, Lewis M, Cooper GM.. High dependency care in an obstetric setting in the UK. Anaesthesia 2008:63, 1081–6.

Maternal Morbidity Category
(See page 5 for definitions)

Please tick all that apply

1. Major obstetric haemorrhage (MOH) ☐	☐ Estimated blood loss ≥ 2500mls
*please identify the criteria met for MOH in the opposite column accordingly. More than 1 can apply	☐ Transfused with ≥ 5 units of blood
1.b Please indicate if the woman received treatment for coagulopathy (fresh frozen plasma, Fibrinogen Concentrate Substitution Therapy, Platelets)	☐ Received treatment for coagulopathy
2. Uterine rupture	
3. **Peripartum hysterectomy** (PH) *please specify indication for PH in text box below	
4. Eclampsia	
5. Renal or liver dysfunction	
6. Pulmonary oedema	
7. Acute respiratory dysfunction	
8. Pulmonary embolism	
9. Cardiac arrest	
10. Coma	
11. Cerebro-vascular event	
12. Status epilepticus	
13. Septicaemic shock	
14. Anaesthetic problem	
15. ICU/CCU admission* ***please specify indication for admission** **Duration of ICU care in days/ part days (e.g. 1.5 days)**	
16. Other severe morbidity, please specify	
17. **Interventional radiology (IR)**	

Please use this space to enter any additional relevant information.

Maternal Morbidity Definitions		
1	Major obstetric haemorrhage	Estimated blood loss ≥ 2500ml, or transfused 5 or more units of blood (Also includes ectopic pregnancy meeting these criteria).
2	Uterine rupture	A complete separation of the wall of the pregnant uterus, with or without expulsion of the fetus, involving rupture of membranes at the site of the uterine rupture or extension into uterine muscle separate from any previous scar, and endangering the life of the mother or fetus. Excluded: any asymptomatic palpable or visualised defect (e.g. dehiscence noted incidentally at caesarean delivery)
3	Peripartum hysterectomy	Peripartum hysterectomy
4	Eclampsia	Seizure associated with antepartum, intrapartum or postpartum symptoms and signs of pre-eclampsia
5	Renal or liver dysfunction	Acute onset of biochemical disturbance, urea >15mmol/l, creatinine>400mmol/l, AST/ALT >200u/l
6	Pulmonary oedema	Clinically diagnosed pulmonary oedema associated with acute breathlessness and O_2 saturation <95%, requiring O_2, diuretics or ventilation
7	Acute respiratory dysfunction	Requiring intubation or ventilation for >60 minutes (not including duration of general anaesthetic)
8	Pulmonary embolism	Increased respiratory rate (>20/min), tachycardia, hypotension. Diagnosed as "high" probability on V/Q scan or positive spiral chest CT scan. Treated by heparin, thrombolysis or embolectomy
9	Cardiac arrest	No detectable major pulse
10	Coma	Including diabetic coma. Unconscious for >12 hours
11	Cerebro-vascular event	Stroke, cerebral/cerebellar haemorrhage or infarction, subarachnoid haemorrhage, dural venous sinus thrombosis
12	Status epilepticus	Constant or near constant state of having seizures that last 30mins or more
13	Septicaemic shock	Sepsis induced tissue hypoperfusion or hypotension persisting after resuscitation with 30mls/kg intravenous isotonic crystalloid fluid as evidenced by: – Systolic blood pressure < 90 mmHg or MAP < 65 mmHg – Decrease in systolic blood pressure by 40mmHg from baseline and/or – Lactate > 4 mmol/l.
14	Anaesthetic problem	Aspiration, failed intubation, high spinal or epidural anaesthetic
15	ICU/CCU admission	Unit equipped to ventilate adults. Admission for one of the above problems or for any other reason. Includes CCU admissions
16	Other severe morbidity	Other severe morbidity, e.g. amniotic fluid embolism
17	Interventional radiology	Received planned (a) or unplanned (b) interventional radiology

Please notify all categories of Severe Maternal Morbidity, as outlined above, occurring during pregnancy or up to 42 days following delivery, miscarriage, termination of pregnancy or ectopic pregnancy.

Thank you for taking the time to complete this form.
The NPEC is sincerely grateful for your contribution to this audit.

Queries and form submission

Please submit completed forms to:

Edel Manning
Project Manager
The National Perinatal Epidemiology Centre
Department of Obstetrics and Gynaecology
5th Floor, Cork University Maternity Hospital
Wilton
Cork

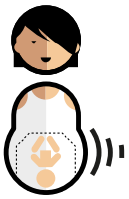
If you have questions or difficulties regarding any aspect of the form, please do not hesitate to contact the NPEC team by telephone: **021 4205042** or by email: **npec@ucc.ie**

Acknowledgement

NPEC would like to acknowledge with thanks the Reproductive Health Programme of the National Health Service (NHS) Quality Improvement Scotland for permission to modify and use their Scottish Confidential Audit of Severe Maternal Morbidity notification form for a similar audit in Ireland.

Appendix F: The Ten Group Classification System (TGCS)[36]

GROUP 1

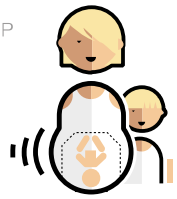


Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour

GROUP 2

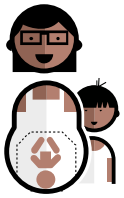
Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation who either had labour induced or were delivered by caesarean section before labour

GROUP 3



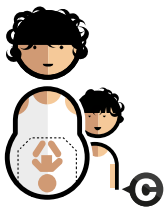
Multiparous women without a previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour

GROUP 4



Multiparous women without a previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation who either had labour induced or were delivered by caesarean section before labour

GROUP 5



All multiparous women with at least one previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation

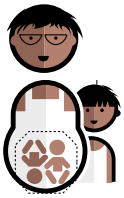
GROUP 6

All nulliparous women with a single breech pregnancy

GROUP 7

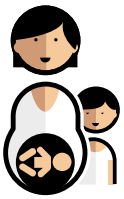
All multiparous women with a single breech pregnancy, including women with previous uterine scars

GROUP 8



All women with multiple pregnancies, including women with previous uterine scars

GROUP 9



All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars

GROUP 10

All women with a single cephalic pregnancy <37weeks gestation, including women with previous scars

36 Robson Classification: Implementation Manual. Geneva: World Health Organization; 2017. Licence: CCBY-NC-SA3.0IGO.

Appendix G: Data Quality Statement for the Audit on Severe Maternal Morbidities

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

Data Quality Statement
National Clinical Audit of Severe Maternal Morbidity

Reference Number: NPEC-DQS-NCAoSMM-01.18

Revision Number: 01

Author: National Perinatal Epidemiology Centre

Approved by: Richard Greene, Director, National Perinatal Epidemiology Centre

Effective from: March 2019
Reviewed and updated January 2021

Next review: January 2023

Signatures of all parties responsible

Richard A Greene, Director,
National Perinatal Epidemiology Centre

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

Data Quality Statement
National Clinical Audit of Severe Maternal Morbidity

1.0 Introduction

Severe Maternal Morbidity (SMM) has been acknowledged internationally as an important quality indicator of obstetric care and maternal welfare, particularly in developed countries where maternal death rates are relatively low. Further, there is evidence that commonly occurring life-threatening complications during or shortly after pregnancy, such as major obstetric haemorrhage (MOH), are under reported as they less frequently lead to death in high-resourced countries. In this context, the NPEC in collaboration with the NPEC Severe Maternal Morbidity Group, has collected and analysed data on SMM from Irish maternity units since 2011. The fundamental aim of the audit is to provide a national review of clearly defined severe maternal morbidities, to identify quality improvement initiatives and make recommendations for the improvement of maternal care for women in Ireland.

2.0 Data collection for the National Clinical Audit of Severe Maternal Morbidity

Data is collected on SMM events occurring between 1 January and 31 December each year. These are submitted using a standardised notification dataset, either electronically via the secure online NPEC database or alternatively by paper format (See Appendix E). The dataset is completed based on data on maternal and fetal characteristics recorded in clinical records. The data are subsequently processed by NPEC in a pseudonymised format, which means that they cannot be attributed to a specific individual without the use of additional information, and only the submitting unit has access to this information.
To allow for international comparison, the NPEC adapted the validated methodology of the Scottish Confidential Audit of Severe Maternal Morbidity (SCASMM) to evaluate severe maternal morbidity (SMM) in Ireland. This methodology utilises organ dysfunction criteria described by Mantel et al., with modifications used by SCASMM to include intervention- based criteria. Implemented nationally in 2011, this data collection tool, adapted for the Irish setting, has been endorsed by the Clinical Advisory Group at the Institute of Obstetrics and Gynaecology and the HSE National Obstetric Programme Working Group.

3.0 Dimensions of data quality for the National Clinical Audit of Severe Maternal Morbidity

The quality of data are defined and assessed here using the internationally accepted dimensions recommended by HIQA[1]:
1. Relevance
2. Accuracy and reliability
3. Timeliness and punctuality
4. Coherence and comparability
5. Accessibility and clarity

[1] Health Information and Quality Authority, (2018) Guidance on a data quality framework for health and social care. https://www.hiqa.ie/sites/default/files/2018-10/Guidance-for-a-data-quality-framework.pdf

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

Data Quality Statement
National Clinical Audit of Severe Maternal Morbidity

3.1 Relevance

Processes are in place to regularly monitor the relevance and use of existing data in meeting the needs of data users and other stakeholders. Regular consultation with data users and other stakeholders is undertaken. These are structured consultation activities focussing on the content and the quality of the data collected, the outcomes, continuous operational improvements, future direction and potential needs.

3.2 Accuracy and reliability

The population of reference is explicitly stated in all releases. Coverage rates are documented. Internal procedures and guidelines for data quality assessment exist and include data cleaning and validation procedures regarding data submitted through both the online and paper formats. The NPEC online database incorporates a suite of validation checks for accuracy. Data cleaning and correction processes are consistently applied: these include checks on the structure and integrity of the data, checks for missing data, checks that the data conforms to data source specifications and checks for outliers.

3.3 Timeliness and punctuality

The NPEC works closely with its data providers to ensure timely submission of data. The NPEC makes data providers aware of submission dates, nevertheless, data collection is done by staff without specific protected time for this purpose. Thus, at times, an extension of the submission dates may be required so as to allow submission of complete and accurate data. Planned releases occur within a reasonable period of time from the end of the reference period. Currently within 18 months of year end of the year under audit, in line with current guidelines.

3.4 Coherence and comparability

Assessments of compliance with terminology standards are regularly undertaken to ensure the data collection is compliant with international and national standards, including clinical guidelines and current best practise. The following are applied:

- Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive;
- World Health Organisation, The WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM 2012 France.

- Evaluating the quality of care for severe pregnancy complications. The WHO near-miss approach for maternal health. World Health Organization; 2011
- Robson Classification: Implementation Manual. Geneva: World Health Organization; 2017. Licence: CCBY-NC-SA3.0IGO
- Data on management of delivery is benchmarked against national standards (IOG, RCPI and HSE, 2011).

Divergences originating from different sources are identified and reasons are clearly and publically explained. For example, severe maternal morbidity and specific morbidity (e.g. MOH) rates are calculated differently by various countries and institutions based on the definition used. Updates in criteria and definitions (e.g. for case ascertainment or classification of specific SMMs) are also clearly explained and clarified with a transition period being applied to guarantee comparability.

Geographic variation limitations, that impact analysis and interpretation, are documented for users.

3.5 Accessibility and clarity

The Annual Report for the National Clinical Audit of Severe Maternal Morbidity, its related lay summary and applied data collection forms are publically available on the NPEC website: https://www.ucc.ie/en/npec/npec-clinical-audits/severematernalmorbidityaudit/

Research output from the audit is catalogued according to individual staff members and publically available on IRIS, ResearchGate, Linkedin or other research information systems. Methodologies are outlined in all published outputs.

The NPEC operates a Data Access Policy in which clear policies and procedures are outlined for data users in relation to the process of accessing and requesting data.

4.0 Further information on the National Clinical Audit of Severe Maternal Morbidity

Further information on the NPEC's Severe Maternal Morbidity Audit can be found at:

https://www.ucc.ie/en/npec/npec-clinical-audits/severematernalmorbidityaudit/

Alternatively please contact us at:

npec@ucc.ie or
National Perinatal Epidemiology Centre,
Dept. of Obstetrics and Gynaecology,
5th Floor Cork University Maternity Hospital,
Wilton,
Cork T12 YE02

Appendix H: Hospital names listed in Figures 5 and 6

A - South Tipperary General Hospital (STGH);

B - University Hospital Kerry (UHK);

C – Cavan General Hospital (CGH);

D – Sligo University Hospital (SUH);

E - St Luke's Hospital, Kilkenny (SLHK);

F - Midland Regional Hospital, Portlaoise (MRHP);

G – Mayo University Hospital, Castlebar (MUH);

H - Portiuncula University Hospital, Ballinasloe (PUH);

I – Letterkenny General Hospital (LUH);

J - Wexford General Hospital (WGH);

K - University Hospital Waterford (UHW);

L - Regional Hospital, Mullingar ((RHM);

M - University Hospital Galway (UHG);

N - Our Lady of Lourdes Hospital, Drogheda (OLOL);

O – Limerick University Maternity Hospital (UMHL);

P - Cork University Maternity Hospital (CUMH);

Q - Coombe Women and Infants University Hospital (CWIUH);

R - National Maternity Hospital (NMH);

S – Rotunda Hospital, Dublin (RH).

Appendix I: Definitions on Levels of Care[37]

Examples of Matemity Care Required at ICS Levels of Support for Critical Care (Saravanakumar et al., 2008)

Level of Care	Maternity Example
Level 0: Normal ward care	Care of low risk pregnant woman
Level 1: **Additional monitoring or intervention,** **or** **step down from higher level of care**	• Risk of haemorrhage • Oxytocin infusion • Mild preeclampsia on oral anti-hypertensive fluid restriction etc. • A woman with a medical condition such as congenital heart disease, or insulin dependent diabetes.
Level 2: Single organ support	**Basic Respiratory Support (BRS)** • 50% or more oxygen via face-mask to maintain oxygen saturation • Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP) **Basic Cardiovascular Support (BCVS)** • Intravenous anti-hypertensive, to control blood pressure in pre-eclampsia • Arterial line used for pressure monitoring or sampling • CVP line used for fluid management and CVP monitoring to guide therapy **Advanced Cardiovascular Support (ACVS)** • Simultaneous use of at least two intravenous, anti-arrhythmic/anti-hypertensive/vasoactive drugs, one of which must be a vasoactive drug • Need to measure and treat cardiac output **Neurological Support** • Magnesium infusion to control seizures (not prophylaxis) • Hepatic support • Management of acute fulminant hepatic failure, e.g. from HELLP syndrome or acute fatty liver, such that transplantation is being considered
Level 3: Advanced respiratory support alone, or support of two or more organ systems above	**Advanced Respiratory Support** • Invasive mechanical ventilation **Support of two or more organ systems** • Renal support and BRS • BRS/BCVS and an additional organ supported • Intracranial ressure monitorin

37 Clinical Practice Guideline No 30 (2014). Guideline for the Critically Ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive

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